

ADA 029331

TECHNICAL REPORT  
NATICK/TR-78/012

**AN ANNOTATED BIBLIOGRAPHY OF  
U.S. ARMY ANTHROPOLOGY  
(1947-1977)**

by

**Robert M. White**

**December 1977**

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**UNITED STATES ARMY  
NATICK RESEARCH and DEVELOPMENT COMMAND  
NATICK, MASSACHUSETTS 01760**



**Clothing, Equipment & Materials Engineering Laboratory  
CE&MEL-170**

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM												
1. REPORT NUMBER NATICK/TR-78/012	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER												
4. TITLE (and Subtitle)  AN ANNOTATED BIBLIOGRAPHY OF U. S. ARMY ANTHROPOLOGY (1947-1977)		5. TYPE OF REPORT & PERIOD COVERED  Technical Report												
		6. PERFORMING ORG. REPORT NUMBER CEMEL-170												
7. AUTHOR(s)  Robert M. White		8. CONTRACT OR GRANT NUMBER(s)												
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Natick Research and Development Command ATTN: DRDNA-VCA Natick, Massachusetts 01760		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62723A 1L762723AH98-AC-002												
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Natick Research and Development Command ATTN: DRDNA-VCA Natick, Massachusetts 01760		12. REPORT DATE December 1977												
		13. NUMBER OF PAGES 169												
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report)  Unclassified												
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE												
16. DISTRIBUTION STATEMENT (of this Report)  Approved for public release; distribution unlimited.														
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)														
18. SUPPLEMENTARY NOTES														
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)  <table border="0"> <tr> <td>ARMY</td> <td>HUMAN FACTORS ENGINEERING</td> <td>CLIMATE</td> </tr> <tr> <td>BIBLIOGRAPHY</td> <td>HUMAN BODY</td> <td>ENVIRONMENT</td> </tr> <tr> <td>ANTHROPOLOGY</td> <td>BODY BUILD</td> <td>ENVIRONMENTAL PROTECTION</td> </tr> <tr> <td>ANTHROPOMETRY</td> <td>DATA</td> <td>IDENTIFICATION (HUMAN)</td> </tr> </table>			ARMY	HUMAN FACTORS ENGINEERING	CLIMATE	BIBLIOGRAPHY	HUMAN BODY	ENVIRONMENT	ANTHROPOLOGY	BODY BUILD	ENVIRONMENTAL PROTECTION	ANTHROPOMETRY	DATA	IDENTIFICATION (HUMAN)
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  <p>A bibliography of U. S. Army publications in the field of physical anthropology has been prepared, covering a period of 30 years and containing 123 references. The annotated bibliography includes technical reports, contract reports, journal articles, papers presented at scientific meetings, books and conference proceedings. Three general areas of research are identified in the bibliography: anthropometry and applications of anthropometric data; constitutional and environmental anthropology; and human identification.</p>														

## PREFACE

Research in physical anthropology in the United States Army is primarily in the field of anthropometry and in the applications of anthropometric data in research and development programs. A complete and up-to-date bibliography of reports of U. S. Army research in anthropology has not been available before in published form. The present bibliography covers a period of 30 years and contains over 100 references. The bibliography includes titles of technical reports, contract reports, journal articles, papers presented at scientific meetings, and books and conference proceedings. Three general areas of research are identified in the bibliography: anthropometry and the applications of anthropometric data; constitutional and environmental anthropology; and human identification.

Anthropometry as a specialized part of physical anthropology is discussed in the Introduction (Section 1). The program of research in anthropology in the U. S. Army is reviewed in Section 2. The Army bibliography and a summary of the subject matter of the bibliography are discussed in Sections 3 and 4. A brief review of the organizational background of anthropology in the U. S. Army is given in Section 5.

Section 6 of the bibliography consists of a chronological listing of titles, beginning in 1947 and ending with the most recent reports published in 1977. The main part of the bibliography is in Section 7, which is an annotated listing of Army publications in anthropology. Here each title is followed by a summary of the contents of the publication; for the most part, these have been taken directly from the publication. In the case of papers presented, published abstracts of the papers are given; in a few instances, the abstracts were not available. In order to facilitate ready reference, a topical listing of the publications is given in Section 8. This contains a summary or outline of the various types of publications which are identified by short descriptive titles to indicate their content. Section 9 consists of an alphabetical listing of authors, with the reference numbers of their publications. A list of references is given in Section 10.



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# AN ANNOTATED BIBLIOGRAPHY OF U. S. ARMY ANTHROPOLOGY (1947-1977)

## 1. INTRODUCTION

Anthropology is the scientific study of man, and as such, includes a wide range of investigation and research. Thus, anthropology consists of several major fields of inquiry, such as physical anthropology, archaeology, cultural or social anthropology, and linguistics. None of these specialized fields is mutually exclusive; they are all interrelated to some degree, and they all also are interrelated with other social or behavioral sciences.

Physical anthropology traditionally includes investigations and studies of fossil man (paleoanthropology), human and primate evolution, classification and race, growth and human development, as well as the size, shape, and structure of the human body. Physical anthropology as a discipline is usually considered to be more of a biological science than social or behavioral; in fact it is sometimes called biological anthropology. Physical anthropology also is closely interrelated with other fields, such as medicine and anatomy, physiology, biochemistry, psychology, and engineering.

As physical anthropology has grown and developed, the range of investigation and research in this area also has broadened in scope. Physical anthropologists recover and study fossils; some teach anatomy and carry on research in morphology, growth and development; some are interested in man's physiology, function, and biological behavior and adaptation; while others are concerned with human evolution and racial development. Anthropologists also specialize in human genetics or in biochemistry and blood-typing. The identification of skeletal remains, pathology (especially paleopathology), and forensic medicine are other areas of specialization.

A recognized, as well as important part of physical anthropology is anthropometry — the measurement of the human body. Techniques of measurement have been developed and used not only for bones and skeletons, whether fossil or recent, but also on the living. Initially, many groups of people, whether "primitive" or "modern", were measured largely for purposes of classification or racial definition. More recently, the practical aspects of anthropometry have become recognized and are receiving increased attention. Anthropometry and the analyses of anthropometric data represent techniques of measuring the human body and statistical treatment of the resulting information in order to define the physical characteristics of human variation in size, shape, and proportions. In recent years, anthropometry has become closely associated with the field of human engineering, which has to do with the integration, compatibility, safety, and comfort involved between man and the machines or equipment he uses or operates. Thus, anthropometry now includes the collection and analyses of anthropometric data, as well as the utilization and application of such data wherever information on human body size is required for purposes of design and sizing.



## 2. ANTHROPOLOGY IN THE UNITED STATES ARMY

Research in physical anthropology in the U. S. Army is primarily in the field of anthropometry and in the applications of anthropometric data. The utilization of anthropometric data in the form of information on body size is of importance in the Army, whether in the design, sizing, and fit of military clothing and individual equipment or in the human engineering of vehicles, aircraft, or other weapons systems.

Military interest in anthropometry is not new or recent; data on the body size of soldiers were collected during and after the Civil War if not before.<sup>1,2</sup> A monumental anthropometric study of Army men, both inductees and separatees, was carried out during World War I by anthropologists who analyzed the data from the standpoint of medical or clinical interest, as well as for the purpose of applications in the design and sizing of military clothing.<sup>3</sup>

Throughout World War II, anthropologists in the Army Air Forces pioneered in the practical applications of anthropometric data in the design, development, and sizing of aircraft cockpits, gun turrets, flight clothing and equipment — even before this type of research became known as human engineering.<sup>4</sup>

At the end of the war, large numbers of both men and women in the Army were measured at separation centers during an anthropometric survey carried out by the U. S. Army Quartermaster Corps in 1946. The results of this survey were published in a series of reports, and the anthropometric data were utilized extensively over a period of some 20 years.

<sup>1</sup>Gould, B. A. Investigations in the Military and Anthropological Statistics of American Soldiers, For the U. S. Sanitary Commission. Hurd and Houghton, New York, N.Y., 1869.

<sup>2</sup>Baxter, J. H. Statistics, Medical and Anthropological, of the Provost Marshal General's Bureau, Derived from Records of the Examination for Military Service in the Armies of the United States During the Late War of the Rebellion of Over a Million Recruits, Drafted Men, Substitutes, and Enrolled Men. 2 volumes. Government Printing Office, Washington, D. C., 1975.

<sup>3</sup>Davenport, C. B., and A. G. Love. The Medical Department of the United States Army in the World War, Volume 15, Statistics; Part 1, Army Anthropology. Government Printing Office, Washington, D. C., 1921.

<sup>4</sup>Randall, Francis E., Albert Damon, Robert S. Benton, and Donald I. Patt. Human Body Size in Military Aircraft and Personal Equipment. Army Air Forces Technical Report No. 5501, Air Materiel Command, Wright Field, Dayton, Ohio, June, 1946. (ATI 25 419)

However, prior to this major anthropometric survey, two significant anthropometric studies were carried out in the Army — significant, as they are the only such specialized anthropometric studies carried out in the United States. They are cited here since the results have had such widespread utilization and application. The first of these consisted of the collection of anthropometric data on the heads and faces of over 3000 Army men, primarily for the design and sizing of gas masks.<sup>5,6</sup> These data were analyzed and subsequently utilized to model a set of ten bronze headforms which are still in use today — 30 years later. In the second study, 27 anthropometric measurements of the feet of over 7500 Army men were made in a survey at Fort Knox, Kentucky.<sup>7</sup> The data from this study have been utilized extensively in the design and sizing of military footwear.

After the U. S. Air Force was established as a separate branch of the Armed Forces, Air Force anthropologists carried out an anthropometric survey of flying personnel in 1950, followed by surveys of male and female basic trainees in 1952. More recently, the Air Force conducted anthropometric surveys of trainees in 1965, of flying personnel in 1967, and of Air Force women (WAF) in 1968. The Army and the Air Force (the only military services to employ physical anthropologists in research) have actively cooperated in the field of anthropology, and anthropologists of both services have frequently exchanged data and worked together on problems of mutual interest.

An anthropometric survey of draftees, enlistees, and re-enlistees was carried out in the Army in 1949, primarily to obtain body size information on younger men. As a result of increasing emphasis on human engineering and the need for specific information on Army aviation personnel, and anthropometric survey of Army aviators was conducted for the first time in 1959, followed by surveys of warrant officer candidate flight trainees in 1969, and of Army aviation personnel again in 1970. Twenty years after the Army survey of 1946, an Army-wide anthropometric survey of men was carried out in

<sup>5</sup> C. W. S. Anthropometric Data on Faces and Heads. C. W. S. Pamphlet No. MIT 1, Chemical Warfare Service Development Laboratory, Massachusetts Institute of Technology, Cambridge, Mass., April, 1945.

<sup>6</sup> Brues, Alice M. Study of Anthropometric Data. M.I.T. — M.R. No. 166, Chemical Warfare Service Development Laboratory, Massachusetts Institute of Technology, Cambridge, Mass., September, 1945 (ATI 128 658)

<sup>7</sup> Freedman, Arthur, Everett C. Huntington, George C. Davis, Richard B. Magee, Valgene M. Milstead, and Charles M. Kirkpatrick. Foot Dimensions of Soldiers. Project T-13, Armored Medical Research Laboratory, Fort Knox, Kentucky, March, 1946. (AD 658 682)



1965-1966. In conjunction with the Army survey, the Army measuring teams also measured samples of the U. S. Marines and of Navy recruits in 1966. With the increasing importance of women in the Army, an anthropometric survey of Army women was conducted in 1976-1977, thus updating the data first obtained on women in 1946. At the end of the women's survey, a small sample of Army men also was measured. A unique additional feature of this survey was the collection of data on workspace measurements and on static muscle strength measurements, thus providing comparable data on both men and women in the Army.

Most of the anthropometric data collected in surveys in the Army over a period of 30 years has been published in technical reports, as reflected in the present bibliography. Additionally, anthropometric data have been included in a number of reports or other publications dealing with the research and development of clothing or items of individual equipment.

Anthropometric data are now published also in official military documents, such as military standards or military handbooks. Four examples of this type of publication may be referenced here:

Van Cott, Harold P., and Robert G. Kinkade (editors), Human Engineering Guide to Equipment Design (Revised edition). U. S. Government Printing Office, Washington, D. C., 1972. (AD 758 339)

Military Standard: Human Engineering Design Criteria for Military Systems, Equipment and Facilities. MIL-STD-1472B, U. S. Department of Defense. Government Printing Office, Washington, D. C., December, 1974.

Military Standardization Handbook: Human Factors Engineering Design for Army Materiel. MIL-HDBK-759, U. S. Department of Defense, Government Printing Office, Washington, D. C., March, 1975.

Engineering Design Handbook: Metric Conversion Guide. DARCOM Pamphlet 706-470, Hq, U. S. Army Materiel Development and Readiness Command. Government Printing Office, Washington, D. C., July, 1976.

The interest in and demand for anthropometric data as a primary source of information on body size is constantly increasing. In addition to the Department of Defense, many other government agencies (National Bureau of Standards, Consumer Product Safety Commission, Federal Aviation Administration, Department of Transportation, Department of Commerce, Department of Health, Education and Welfare, for example) have a need for anthropometric data for use in the development of standards and other applications. Many groups and organizations in industry (such as the Society of Automotive Engineers and the American Society of Mechanical Engineers) seek anthropometric data for utilization and application in product design, development, and improvement. Anthropometric data particularly are needed in the clothing and apparel

industry for the development and improvement of sizing standards for clothing, as well as headwear, handwear, and footwear. Unfortunately the anthropometric data which are currently available for the U. S. civilian population of men, women, and children are incomplete, inadequate, or actually lacking. For this reason, in many instances, data on military men and women are the only source of the required information on body size. Anthropometric data collected and published by the Army or the Air Force thus are widely used as the only such information available.

### 3. THE ARMY BIBLIOGRAPHY

Since a complete and up-to-date bibliography of reports of U. S. Army research in anthropology has not been available before in published form, the present bibliography fills a long-felt need. The bibliography represents a summary of Army research in anthropology and its applications in military research and development programs over a period of years. To some extent at least, the contents of the bibliography reflect Army requirements in the field of applied anthropology and also indicate the interests of the individuals engaged in research in this field.

Section 6 of the bibliography consists of a chronological listing of titles, beginning in 1947 and ending with the most recent reports published in 1977. The main part of the bibliography is in Section 7, which is an annotated listing of U. S. Army publications in anthropology. Here each title is followed by a summary of the contents of the publication; for the most part these have been taken directly from the publications. In the case of papers presented, published abstracts of the papers are given; in a few instances, the abstracts were not available. In order to facilitate ready reference, a topical listing of the publications is given in Section 8. This contains a summary or outline of the various types of publications which are identified by short descriptive titles to indicate their content. Section 9 consists of an alphabetical listing of authors of the Army publications. A list of references is given in Section 10.

Many interesting references to early military anthropology and its applications may be found in:

Ruth O'Brien. An Annotated List of Literature References on Garment Sizes and Body Measurements. Miscellaneous Publication No. 78, U. S. Department of Agriculture, Washington, D. C., May, 1930.

Some of the older Army reports in anthropology were referenced and annotated in:

Robert Hansen and Douglas Y. Cornog; H. T. E. Hertzberg (editor). Annotated Bibliography of Applied Physical Anthropology in Human Engineering. WADC Technical Report 56-30, Aero Medical Laboratory, Wright-Patterson Air Force Base, Ohio, May, 1958. (AD 155 622)



Another useful bibliography, also containing summaries of older Army reports in anthropology, is:

M. S. Staples. A Bibliographical Survey and Critical Review of the Role of Anthropometry in the Sizing of Clothing and Personal Equipment. Survey carried out for the Defence Research Board (DRB) by the Ontario Research Foundation, Toronto, December, 1964; reprinted by the Defence Research Board, Ottawa, Canada, June, 1965.

Unfortunately many of the older Army reports in anthropology (prior to 1960) now are out of print or not readily available. However, the titles of technical reports in the bibliography are followed by an "AD" number; this is the accession number under which qualified requestors (Department of Defense agencies and contractors) may obtain the document from the Defense Documentation Center (DDC), Cameron Station, Alexandria, Virginia 22314. Others may purchase the report from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22151.

#### 4. SUBJECT MATTER OF THE BIBLIOGRAPHY

The bibliography of U. S. Army publications in the field of physical anthropology covers a period of 30 years and contains 123 titles. An analysis of the references in the bibliography by subject matter indicates three general areas of research: anthropometry and various applications of anthropometric data; constitutional and environmental anthropology; and human identification. Approximately three-quarters of the references in the bibliography were authored by five physical anthropologists who were employed by the U. S. Army at various times during the 30-year period: Francis E. Randall, Robert M. White, Russell W. Newman, Paul T. Baker, and Thomas W. McKern.

In the area of anthropometric surveys are included reports on the U. S. Army Quartermaster survey of both men and women, carried out in 1946, and on the survey of U. S. Army men in 1966. Anthropometric surveys of U. S. Army aviators were conducted in 1959, 1969, and 1970. The most recent anthropometric survey was that of U. S. Army women, carried out in 1976-1977.

Army personnel also have directed or participated in anthropometric surveys in several foreign countries. While some of the reports on these foreign surveys are not, strictly speaking, U. S. Army reports, they are included here for completeness. Reports on foreign anthropometric surveys include those of Turkey, Greece, and Italy in 1960-1961, Thailand in 1962, Vietnam in 1963, and Korea in 1965. A survey to collect anthropometric data on military personnel of some 18 Central and South American countries was carried out between 1965 and 1970 at the U. S. Army Tropic Test Center in the Canal Zone. U. S. Army personnel supported and participated in an anthropometric survey of military personnel in Iran in 1968.

Research in constitutional and environmental anthropology was carried out primarily by Newman and Baker between 1952 and 1963. Their technical reports and articles discuss body build, the measurement of skinfold thickness (as an estimate of body fat), and various aspects of environmental stress and adaptations thereto. Hooton's reports between 1948 and 1951, presenting the results of contract research at Harvard University, contain material on both anthropometry and somatotype or body build.

Research in human identification (specifically, identification of the remains of war dead) was carried out by Newman, Baker, and McKern between 1956 and 1960. Significant contributions in this area also were made by Trotter and Gleser, and Sassouni, whose research was carried out under contract. It may be noted that the results of this research in identification have been incorporated into the latest edition of the U. S. Army Field Manual on Identification of Deceased Personnel (FM 10-286, 1976).

The largest category of publications in the bibliography consists of 53 technical reports of research carried out in U. S. Army laboratories. Fourteen titles in the bibliography refer to contract reports or publications of contractor's reports of research conducted primarily at universities or other research institutions. Journal articles account for 21 references in the bibliography, while 33 references represent papers presented at scientific meetings or conferences. A miscellaneous category includes eight references to book chapters or to papers in conference proceedings published in book form.

Of the 53 technical reports, 12 references report on the methodology and results of major anthropometric surveys, 17 references contain other presentations of anthropometric data, and 15 references discuss various applications of anthropometry in research and development. Six technical reports have to do with skinfold thickness and body fat or acclimatization to environmental stress. Three technical reports are in the area of human identification.

Of the 14 contract reports, seven deal with anthropometry, six discuss or illustrate body build, and one presents a specialized technique of identification.

Among the 21 references representing journal articles, five discuss anthropometry or its applications, nine have to do with body build or environmental acclimatization, while six present various aspects of identification. Three of the latter journal articles report the results of research carried out under contract. One journal article consists of an obituary of Francis E. Randall, who initiated the Army program of research in physical anthropology in 1946; he died in an airplane crash in 1949. Most of the journal articles (13) were published in the **American Journal of Physical Anthropology**, while five appeared in **Human Biology**, and three in other journals.

Of the 33 papers presented at scientific meetings, 17 discuss anthropometry or its applications, 13 deal with body build or acclimatization, and three have to do with identification. Twenty-three of the papers were presented at annual meetings of the



American Association of Physical Anthropologists between 1950 and 1966; abstracts of these papers were published in the **American Journal of Physical Anthropology**. Ten additional papers were presented at other scientific meetings or conferences; four of these were published in the proceedings of these meetings.

As noted above, this bibliography has been limited to publications in Army anthropology consisting of technical reports, journal articles, papers presented, and books or conference proceedings. The titles of approximately 90 minor reports in Army anthropology (such as memorandum reports, letter reports, and research study or test reports) have not been included. These are short or brief reports dealing with anthropometric analyses or applications, written primarily for internal use in Army research and development programs. In a sense, most of these short reports are not "publications" in the generally accepted definition of the term.

## 5. ORGANIZATIONAL BACKGROUND

An historical note may help to explain and clarify some of the confusing organizational references in the Army bibliography. The U. S. Army Quartermaster Climatic Research Laboratory, established in Lawrence, Massachusetts, during World War II, operated under the administration of the Environmental Protection Section, Research and Development Branch, Military Planning Division, Office of the Quartermaster General, Department of the Army, Washington, D. C., until September, 1951. The Environmental Protection Section then became a Branch under Research and Development Division. When the U. S. Army Quartermaster Research and Development Command was established at the Quartermaster Research and Development Center, Natick, Massachusetts, in 1953, the Environmental Protection Branch was moved from Washington, D. C. to Natick and raised to Division status. The Climatic Research Laboratory also was moved at this time from Lawrence to Natick and was incorporated into the Environmental Protection Division. Environmental Protection Division was changed to Environmental Protection Research Division in 1956, and the Quartermaster Research and Development Center became the Quartermaster Research and Engineering Center in 1957. With the Army reorganization of 1962 and the disestablishment of the Office of the Quartermaster General, the Quartermaster Research and Engineering Center was placed under the new Army Materiel Command and renamed the U. S. Army Natick Laboratories. When the former Environmental Protection Research Division was abolished in 1961, research activities in the fields of anthropology and psychology were assigned to the Pioneering Research Division at the U. S. Army Natick Laboratories; the Anthropology Laboratory was one of the four Psychology Laboratories under Pioneering Research Division. In 1966, the various Divisions of the U. S. Army Natick Laboratories were redesignated as Laboratories. In 1970, anthropology as a research activity was transferred from Pioneering Research Laboratory to Clothing and Personal Life Support Equipment Laboratory; the latter became the Clothing, Equipment, and Materials Engineering Laboratory in 1974. In 1975, the U. S. Army Natick Laboratories became the U. S. Army Natick Development Center. In 1976, this was again redesignated as the U. S. Army Natick Research and Development Command (NARADCOM), operating under the U. S. Army Materiel Development and Readiness Command (DARCOM).

## 6. CHRONOLOGICAL LISTING OF U. S. ARMY PUBLICATIONS IN ANTHROPOLOGY

1947

- 1 RANDALL, FRANCIS E., and MELVYN J. BAER. Survey of Body Size of Army Personnel, Male and Female; Project No. E-59-46, Phase I, Report No. 1 — Methodology. Report No. 122, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., July, 1947. (AD 149 458)
- 2 RANDALL, FRANCIS E. Survey of Body Size of Army Personnel, Male and Female; Project No. E-59-46, Phase 4, Report No. 1 — Methodology and General Considerations (Female). Report No. 123, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., July, 1947. (AD 209 809)

1948

- 3 BULLEN, ADELAIDE K. Vocational Incidence of Seven Body Types in 547 U. S. Army Women. Contract Report (Contract W44-109-qm-1078), Department of Anthropology, Harvard University, Cambridge, Mass., May, 1948.
- 4 RANDALL, FRANCIS E. Applications of Anthropometry to the Determination of Size in Clothing. Environmental Protection Series Report No. 133, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., June, 1948. (AD 125 753)
- 5 HOOTON, EARNEST A. Body Build in Relation to Military Function in a Sample of the United States Army. Contract Report (Contract W44-109-qm-1078), Department of Anthropology, Harvard University, Cambridge, Mass., September, 1948.
- 6 HOOTON, EARNEST A. Album Illustrating Body Build in Relation to Military Function in a Sample of the United States Army. Contract Report (Contract W44-109-qm-1078), Department of Anthropology, Harvard University, Cambridge, Mass., September, 1948.
- 7 RANDALL, FRANCIS E. Anthropometry in the Quartermaster Corps. American Journal of Physical Anthropology, N.S. Vol. 6, No. 3, 373-380, September, 1948.



1949

- 8 RANDALL, FRANCIS E. Anthropometric Nomograph of Army Men. Environmental Protection Section Report No. 147, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., January, 1949.
- 9 RANDALL, FRANCIS E., and ELLA H. MUNRO. Anthropometric Nomograph of Army Women. Environmental Protection Section Report No. 148, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., February, 1949. (AD 50 737)
- 10 RANDALL, FRANCIS E., and ELLA H. MUNRO. Reference Anthropometry of Army Women. Environmental Protection Section Report No. 149, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., March, 1949. (AD 209 837)
- 11 RANDALL, FRANCIS E. Anthropometric Nomograph of Army Men. (Paper presented at the 18th annual meeting, American Association of Physical Anthropologists, Philadelphia, Pa., April, 1949). American Journal of Physical Anthropology, N.S. Vol. 7, No. 2, 280, June, 1949.
- 12 RANDALL, FRANCIS E. Age Changes in Young Adult Army Males. Human Biology, Vol. 21, No. 3, 187-198, September, 1949.
- 13 HOOTON, EARNEST A. Measurements of Body Build in a Sample of the United States Army. Contract Report (Contract W44-109-qm-2014), Department of Anthropology, Harvard University, Cambridge, Mass., October, 1949.
- 14 RANDALL, FRANCIS E. Anthropometric Nomograph of Army White Men. Human Biology, Vol. 21, No. 4, 218-232, December, 1949.

1950

- 15 WHITE, ROBERT M. Francis Eugene Randall, 1914-1949. American Journal of Physical Anthropology, N.S. Vol. 8, No. 1, 113-117, March, 1950.
- 16 WHITE, ROBERT M. A Summary of Present Research in Army Anthropometry. (Paper presented at the 19th annual meeting, American Association of Physical Anthropologists, Boston, Mass., April, 1950). American Journal of Physical Anthropology, N.S. Vol. 8, No. 2, 272, June, 1950.

## 1951

- 17 HOOTON, EARNEST A., FREDERICK L. STAGG, NATALIE B. STODDARD, and EMMA H. ROBBINS. Handbook of Body Types in the United States Army (White Males). Volume I — Description of Types; Volume II — Plates. Contract Report (Contract W44-109-qm-2241), Department of Anthropology, Harvard University, Cambridge, Mass., January, 1951.
- 18 RANDALL, FRANCIS E., ELLA H. MUNRO, and ROBERT M. WHITE. Anthropometry of the Foot (U. S. Army White Male). Environmental Protection Section Report No. 172, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., January, 1951. (AD 103 423)
- 19 WHITE, ROBERT M., and GERALD WINSTON. A Nine-Size System for Functional Clothing. Environmental Protection Section Special Report No. 50, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., April, 1951.
- 20 NEWMAN, RUSSELL W. Cranial Changes in a Sequential Skeletal Series. (Paper presented at the 20th annual meeting, American Association of Physical Anthropologists, Ann Arbor, Mich., March, 1951). American Journal of Physical Anthropology, N.S. Vol. 9, No. 2, 237, June, 1951.
- 21 WHITE, ROBERT M. Anthropometry and Clothing Sizing. (Paper presented at the 20th annual meeting, American Association of Physical Anthropologists, Ann Arbor, Mich., March, 1951). American Journal of Physical Anthropology, N.S. Vol. 9, No. 2, 242, June, 1951.
- 22 NEWMAN, RUSSELL W. Changes in Body Dimensions During Basic Training in Relation to Clothing Sizes. Environmental Protection Section Report No. 176, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., August, 1951. (AD 148 845)
- 23 NEWMAN, RUSSELL W., and ROBERT M. WHITE. Reference Anthropometry of Army Men. Environmental Protection Section Report No. 180, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., September, 1951. (AD 149 451)
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## 7. ANNOTATED LISTING OF U. S. ARMY PUBLICATIONS IN ANTHROPOLOGY

- 1 RANDALL, FRANCIS E., and MELVYN J. BAER. Survey of Body Size of Army Personnel, Male and Female; Project No. E-59-46, Phase I, Report No. 1 — Methodology. Report No. 122, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., July, 1947. 47 pages (AD 149 458)

The information presented in this report describes the measurement techniques utilized in an anthropometric survey of U. S. Army men carried out in 1946 by the U. S. Army Quartermaster Corps.

The field survey of the anthropometry of men began early in May, 1946, and continued at six different separation centers until November, 1946, with a total of 105,062 men being measured. Of the total measured, 96,381 were being separated from service, or were re-enlisting; 8,681 men were just entering the Army and had had no previous military experience. Of the total 105,062 men, 6,404 were Negro or White-Negro mixture. Physical types were recorded photographically on 49,500 officers and men studied in the survey.

The actual techniques utilized in measuring the subjects are described and illustrated by photographs.

The data collected in this survey are considered adequate for use to establish specifications on the physical size of male military personnel for clothing sizing and tariffing, and for determination of space requirements of personnel. The data are also suitable for a study of the physical type and size of male military personnel in regard to function performed in military occupations and to provide bases for personnel selection and treatment in the future.



- 2 RANDALL, FRANCIS E. Survey of Body Size of Army Personnel, Male and Female; Project No. E-59-46, Phase 4, Report No. 1 — Methodology and General Considerations (Female). Report No. 123, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., July, 1947. 36 pages (AD 209 809)

The information presented in this report concerns methods of measurement and general considerations of the population measured in an anthropometric survey of U. S. Army women carried out in 1946 by the U. S. Army Quartermaster Corps.

A total of 8864 Army women were measured at three Army installations. Sixty-four standard anthropometric and tailoring dimensions were measured. Body build photographs were taken of 555 women at six Army General Hospitals. Of those measured, approximately 5216 were WAC enlisted women and WAC officers, and 3648 were Army nurses; 8559 were White and 305 were non-White. All women measured had had previous military experience.

Descriptions of the measurements and techniques utilized in the survey are presented in this report.

Preliminary analyses of the data on 8258 U. S. born White women for age, weight, and stature have been made and are reported here. These data show that Army WAC enlisted women tend to be the shortest and lightest, WAC officers tend to be tallest and heaviest, as well as oldest, and Army nurses intermediate to the other two groups in stature and weight.

The entire series will provide basic information which will enable clothing and equipment designers to standardize the sizes of their products for use by Army women.

- 3 BULLEN, ADELAIDE K. Vocational Incidence of Seven Body Types in 547 U. S. Army Women. Contract Report (Contract W44-109-qm-1078), Department of Anthropology, Harvard University, Cambridge, Mass., May, 1948. 122 pages

The objective of this study is to determine whether there are distinct constitutional types of women who engage in particular types of military activities and whether there are any desirable selection procedures which might be utilized in the future for the benefit of the Armed Services.

Body build photographs of 547 WAC and Nurse volunteers in six Army General Hospitals were collected and analyzed, together with 38 anthropometric measurements on each subject.

There appear to be some distinct constitutional types of women who tend to engage in particular types of military activities according to the following seven major types of body build distinguished in this study: FAT (Endo), MUSCULAR (Meso), THIN (Ecto), MUSCULAR-FAT (Meso-Endo), MUSCULAR-THIN (Meso-Ecto), PLUMP-DELICATE (Endo-Ecto), and MODERATE MIXTURE.

Most occupational or other categories, although having MODERATE MIXTURES AND THIN women as the leading types, show other distinct differences in trend when compared with each other. As to sizing tariffs, it is important to realize that MODERATE MIXTURES, who show no extreme tendency in body build, tend to be below average in size.

Means of the seven body types vary for the 38 measurements and reflect the direction of the observational criteria for the seven body types. The seven body types show some differences in tendencies to disproportion, lumbar curve shape and placement of hip fat. Foot size and proportion tends to vary with body type. FAT women (relatively common in the Nurse group) tend to have comparatively small, plump feet which carry a heavy body weight.



- 4 RANDALL, FRANCIS E. Applications of Anthropometry to the Determination of Size in Clothing. Environmental Protection Series Report No. 133, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., June, 1948. 108 pages (AD 125 753)

The contents of this report were designed to aid in the understanding of subject matter developed from the analysis of anthropometric data resulting from the survey of body size of male and female Army personnel. The objective of the report is to describe mathematical methods of interpretation of body dimensions for use in the determination of sizes and tariffs of clothing.

Data are presented which will serve to simplify the mathematical concepts involved in application of anthropometric data to clothing size and tariffing problems. An understanding of the contents of this report will aid clothing designers and supply agencies in the utilization of anthropometric data in their respective problems.

- 5 HOOTON, EARNEST A. Body Build in Relation to Military Function in a Sample of the United States Army. Contract Report (Contract W44-109-qm-1078), Department of Anthropology, Harvard University, Cambridge, Mass., September, 1948. 241 pages

The purpose of the present report is to describe the body type (somatotype) composition of a series of United States soldiers studied in the anthropometric survey conducted by the Quartermaster Corps and to make "special group analyses to indicate whether or not there are distinct constitutional types of men and women who engage in particular military activities." The scope of the present report is limited to the distribution of body types among the males and the military and civilian sociological correlates of these types.

The material is a series of 31,658 Whites and 3,051 Negroes. The sample studied represents males accepted for military service; not the total U. S. male population of military age. Since the series was measured in the spring of 1946 and includes 85.53 percent of men who have served 24 months or less, it is clear that it hardly represents, as a whole, seasoned combat veterans. Many of the men must have been inducted in the later wartime drafts.

Body type classification is based upon the study of front, back, and side views of the nude individual, together with data on the relation of height to weight. Three structural body components are considered in the classification: fat development, muscle development, and degree of attenuation or elongation as expressed by the index of height/cube root of weight. Each component is graded on a scale from 1 to 7, by morphological examination in the case of fat and muscle, and by dividing the total range of the height/cube root of weight index into seven equal steps in the case of the third component which grades attenuation. The total body type of the individual is expressed by a three-digit combination, each digit ranging from 1 to 7. Thus, 1-1-7 indicates a body type of minimum fat development, minimum muscle development, and maximum attenuation, or height relative to weight. 4-4-4 indicates an individual at approximately the middle of the range of fat, muscle, and attenuation. These types, numerically designated, are lumped into 18 groups, each containing closely similar types, for purposes of correlation with military specialty and with other sociological phenomena.



- 6 HOOTON, EARNEST A. Album Illustrating Body Build in Relation to Military Function in a Sample of the United States Army. Contract Report (Contract W44-109-qm-1078), Department of Anthropology, Harvard University, Cambridge, Mass., September, 1948. 56 pages

This album illustrates the report BODY BUILD IN RELATION TO MILITARY FUNCTION IN A SAMPLE OF THE UNITED STATES ARMY. The photographs follow the order of body build subgroups listed in Table I, page 12, of the report. The Table is hereinafter reproduced. Each photograph is labeled with the name of the body type subgroup, the numerical designation by components of the specific body type (e.g. 1-1-7), and the classification as to service utility (Combat, General Utility, or Service Type) according to Table ii, page xxi of the report, also hereinafter reproduced. In general, the ordering of the photographs follows that of increasing development of the first structural component (fat), and second structural component (muscle). This involves also increasing values of the third or attenuation component within each subgroup, but a general decrease of attenuation (elongation) through the series of subgroups.

Only a few of the rare and numerically unimportant body types have been included in the illustrations, in order to suggest the wide range of individual body types in the series.

The photographs of the Negro Series, which follow those of the Whites, are ordered in the same manner. Preceding these illustrations is a table of Total Distribution of Body Type Subgroups in the Negro Series.

- 7 RANDALL, FRANCIS E. Anthropometry in the Quartermaster Corps. American Journal of Physical Anthropology, N.S. Vol. 6, No. 3, 373–380, September, 1948.

The entry of anthropologists into military research, in the engineering sense, furthered a new field of endeavor which has come to be called Applied Physical Anthropology. It is the purpose of this paper to give a somewhat broader picture of the Army program and to attempt to describe how anthropometry as a field of endeavor fits into the organization of military research. The application phases fall into two main categories. The first is, to a great extent, pure anthropometry in that it is concerned with the measurement of human beings in considerable detail. The collection of large series of detailed measurements is considered to be of primary value in that the data, when analyzed, will serve to provide a constant source of reliable information upon which further studies may be based. The second phase falls into the category of testing. In this phase, anthropometry is highly specialized in that small numbers of dimensions are taken and quite frequently taken on limited series of individuals which are subsequently evaluated in terms of the initial large series.

This paper, although confined to a brief review of methods of application of anthropometry to military problems, should indicate that there is a very real place for the applied physical anthropologist, not only in military fields of endeavor, but also in all types of industry concerned in the design, development, and fabrication of equipment destined for use by the human being. This situation, only beginning to be realized by responsible personnel in industry, presents a definite challenge to physical anthropologists to produce properly trained personnel who may be equipped to continue the many ramifications of the application of physical anthropology to the comfort and well-being of their fellow men.



- 8 RANDALL, FRANCIS E. Anthropometric Nomograph of Army Men. Environmental Protection Section Report No. 147, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., January, 1949. 20 pages (AD 50 747)

The purpose of this report is to provide a simple source of reference of anthropometric data for use by designers of clothing and other personal equipment.

An analysis of the Army population has been made in order to present the interrelationships which exist between twenty-four bodily dimensions and two independent bodily dimensions, stature and chest circumference.

Resulting from this analysis is a nomograph from which can be easily read the average values of the twenty-four dependent dimensions which will be associated with any selected pair of stature and chest circumference values.

Use of this nomograph will be of aid to the designers and developers of clothing, personal equipment, and other equipment used by Army men.

- 9 RANDALL, FRANCIS E., and ELLA H. MUNRO. Anthropometric Nomograph of Army Women. Environmental Protection Section Report No. 148, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., February, 1949. 13 pages (AD 50 737)

The purpose of this report is to provide a simple source of reference of anthropometric data for use by designers of women's clothing and other personal equipment.

An analysis of an Army female population, 18 to 29 years of age, has been made in order to present the interrelationships which exist between eight bodily dimensions and two independent bodily dimensions, cervicale height and hip circumference.

Resulting from this analysis is a nomograph from which can be easily read the average values of the eight dependent dimensions which will be associated with any selected pair of cervicale height and hip circumference values.

This nomograph will be of aid to the designers and developers of clothing, personal equipment, and other equipment used by Army women.



- 10 RANDALL, FRANCIS E., and ELLA H. MUNRO. Reference Anthropometry of Army Women. Environmental Protection Section Report No. 149, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., March, 1949. 247 pages (AD 209 837) (Oversize format)

The purpose of this report is to provide reference data on the anthropometry of Army women, both Women's Army Corps and Army Nurse Corps, for use by the designers of equipment and clothing intended for use by women in the Army.

One hundred and nine regression tables and ninety-eight bivariate have been prepared to indicate a wide variety of interrelationships of pairs of dimensions which exist on a sample women's population in the Army. These data will serve as a guide to the designers of equipment for use by Army women.

- 11 RANDALL, FRANCIS E. Anthropometric Nomograph of Army Men. (Paper presented at the 18th annual meeting, American Association of Physical Anthropologists, Philadelphia, Pa., April, 1949). American Journal of Physical Anthropology, N.S. Vol. 7, No. 2, 280, June, 1949.

Abstract: In order to reduce anthropometry of Army men to the simplest form for use by non-scientific personnel, a nomograph has been prepared to demonstrate the relationships of 24 other dimensions to stature and chest circumference. This graph is based on a series of 24,500 U. S. Army separations.



- 12 RANDALL, FRANCIS E. Age Changes in Young Adult Army Males. *Human Biology*, Vol. 21, No. 3, 187-198, September, 1949.

We have become so accustomed to thinking of growth as being a process which is involved in the production of the adult that it is extremely difficult to define properly the terminology which should apply to changes which occur after the individual has reached a stage commonly referred to as adult. Adulthood, in itself, is subject to a wide variety of interpretations, in that physiological, psychological, and physical fulfillment may be attained at widely divergent chronological periods.

The length of time beyond age 17 during which increases still occur which may be related to growth has not been clearly demonstrated. How much effect, for instance, does the failure of the vertebral epiphyses to close until age 25 have on the stature of men? Or, disregarding epiphyseal union, when is the maximum stature of American males attained? Is it statistically sound to compare a group of young adults between ages 20 and 24 with another group between 22 and 26 years of age? Once adult stature is reached, is there a period of stability maintained during which it is possible to group young adult males into age groups which would make them mutually comparable? The importance of these questions to the study of human biology is obvious. Would, for example, young men of ages 17, 18, and 19 have the same distributions of bodily dimensions as would young men of ages 20, 21, and 22?

In order to answer the questions posed above, a population of young men was studied. The total series consisted of 17,341 Army men, distributed over the entire United States in close approximation to the manner shown in the U. S. Census Report for 1940. In this series there were approximately 3,000 each of ages 17, 18, and 19; 1,500 of ages 20 and 21; and 1,000 of ages 22, 23, 24, 25, and 26. Owing to the wide distribution over the United States, and to the medical acceptability of the men involved, insofar as the Army was concerned, the series may be considered representative of the healthy American male White adult to a great extent.

All the dimensions studied show changes between 17 and 26. All except one show a positive increase, with inseam being the only one to show a decrease. The greatest change, as might be expected, occurs in weight, which increases from 139.26 pounds at age 17 up to 157.87 pounds at age 26. Next, as also might be expected, is the waist circumference, which increases from 73.2 cm. at 17 to 79.2 cm. at 26. Chest circumference is not far behind, increasing from 87.6 cm. to 93.4 cm. between 17 and 26.

Changes which are basically a result of bony growth show a somewhat different picture. Stature reaches its maximum, in this series, at age 23, 175.1 cm. Even though the mean values indicate maximum attained at age 23, there is no statistically significant change after age 18. Consequently, evidence is strong that the American white male attains his adult stature, as an average, in the 18th year.

It should be clear that we are dealing with a range of years over which some portions of the body have ceased growth, while others are still involved in increase in dimension, even though we may not fully agree on terming this increase growth. Since the increase is open to question in its definition, the logical conclusion must be that the definition of growth must come under new consideration. Certainly the difference in the terms of increase in dimension and growth is subtle, but this very subtlety must be realized before clarification of the terms can be attained. One possible way out of this dilemma is to segregate the concepts into two categories: the cessation of skeletal growth as defined by the closure of epiphyses; and the cessation of growth or increase in dimension of the soft tissues. One objection to this type of consideration is that increasing age, decrease of muscular tonicity, and physical conditioning may all be contributory to a change in dimension which is not a result of growth. Waist circumference would be notable in this respect.

From the standpoint of the human biologist, the variability of successive age groups should certainly serve as a warning to exert extreme care in the weighting of populations for comparative purposes. A common practice, for example, has been to group series into five-year periods, 20—25, 25—30, 30—35, etc., which, on the surface appears quite acceptable. However, if the proportions of ages within the sub-groups differ to any marked degree, highly spurious results may be expected.



- 13 HOOTON, EARNEST A. Measurements of Body Build in a Sample of the United States Army. Contract Report (Contract W44-109-qm-2014), Department of Anthropology, Harvard University, Cambridge, Mass., October, 1949. 304 pages

In the report of September, 1948 (Body Build in Relation to Military Function in a Sample of the United States Army), attention was devoted to: (1) the general distribution of body types classified into 18 groups; (2) the military utility of each of the several groups; and (3) the correlations of the body build groups with all sociological and other data compiled in the survey.

The present report deals with the more important measurements gathered on individual soldiers during the course of the survey, as such measurements apply to the various body types previously determined from the photographs.

Previous work on the metric data deals with separate measurements and combinations of measurements, but is not correlated with the individual body types as studied in this section of the survey. Consequently, this report analyzes some of the more important measurements, showing the extent to which they change with shifts of the three structural bodily components in the many body types recognized. It further takes each body type large enough for analysis and compares it as a metric entity with certain other adjacent or morphologically similar types. It discusses also the detailed distribution of body groups and types in relation to stature and chest girth. Thus the report of this year supplements and completes that of the preceeding year in giving the precise metric descriptions of the body builds which had been summarily classified and related to various facets of military or sociological interest.

- 14 RANDALL, FRANCIS E. Anthropometric Nomograph of Army White Men. Human Biology, Vol. 21, No. 4, 218-232, December, 1949.

The nomograph is a tool which is much more familiar to the physical sciences of chemistry, physics, and engineering than it is to the biological sciences. This is probably because multiple variables are much more commonly used in the experimental phases of those sciences. However, with the extension of physical anthropology into applied fields, it is logical that the development of nomographs and their use will materially facilitate the engineering uses of anthropometry. The usual presentation of anthropometric data in terms of means, modes, medians, standard deviations, etc., quite often fails to present a total picture of the physical dimensional characteristics of a population. A much more descriptive picture might result if the dimensions, related to at least two independent variables, could be presented in terms of space and direction, rather than by cold, dry numbers.

In order to determine accurately the multiple regression equations which are necessary in the preparation of a nomograph, a population of considerable size is required. In the particular case under discussion, a series of 24,500 male, White, Army separates was used. This series is large enough to permit a nationwide distribution representative of the population. Further, this sizeable population permits an adequate definition, and thus may serve as a base reference for future nomographic comparisons. Twenty-five body measurements, together with two dimensions collected on a smaller series, are included in the analysis.

The first step in the preparation of the nomograph is the selection of the two independent variables. Fortunately, in this case, the matter is simplified by the fact that the engineering application and the biological usage involve the same two, stature and chest circumference. Stature is all-inclusive of length, and chest circumference tends to include girth as affected both by the skeleton and soft tissues. The second step is the preparation of a series of distributions of dimensions for each of several incremental categories of stature and chest circumference. This step is not actually required, but is advisable in order to have experimental observations available to check the accuracy of the equations.

The third step is the calculation of regression equations showing the regression of a variable on stature and chest circumference. Concurrent with the third step is the calculation of the standard error of estimate of the regression. Finally, having determined the regression slopes and shapes, the basic data can be used to locate the lines of relationship on the nomograph.

With a nomograph at hand, several facts may be directly assessed. (1) The proportionate degree of correlation of a dependent variable to each of the independent variables. Those dimensions which lie closer to stature than to chest circumference are more highly related to stature than to the girth. The opposite

is, of course, true for those lying closer to chest circumference. (2) A vertical line for the dimension indicates linear regression on both independent dimensions. (3) Dimensions **between** stature and chest are positively related to both. (4) Those dimensions **to the left** of stature decrease with increase in chest girth, and those **to the right** of chest circumference decrease with increase in stature. (5) A dimension sloping up and to the right, but straight, is linear in its regression on stature, but curvilinear in its regression on chest. A slope to the left, progressing upwards, would be the reverse. (6) A curved line indicates a curvilinear regression on both independent variables.

The nomograph then provides a pictogram of a complex of variables, which may be subjectively studied to indicate generally the interrelationships present. Objectively studied, either as a nomograph or as a series of equations, measures of likenesses or differences within and between populations may be determined.



- 15 WHITE, ROBERT M. Francis Eugene Randall, 1914–1949. *American Journal of Physical Anthropology*, N.S. Vol. 8, No. 1, 113–117, March, 1950.

Francis E. Randall lost his life in the crash of a commercial airliner at Washington, D. C. on November 1, 1949. At the time, he was on official travel in connection with his duties as the senior anthropologist in the U. S. Army Quartermaster Corps.

Following undergraduate and graduate work at Western Reserve University in Cleveland (A.B., 1936 and M. A., 1938), Randall completed further graduate work in biology and anthropology at Harvard University and received a Ph.D. degree in 1942. During World War II, he was engaged in anthropological research and human engineering in the Army Air Forces at Wright Field, Dayton, Ohio.

In 1946, Randall began his work in the Army Quartermaster Corps, where he organized and directed the large anthropometric survey of U. S. Army men and women who were measured at separation centers at the end of the war. He then carried out the processing and analyses of the anthropometric data from this survey, and published some twelve major technical reports on the results of this work before his untimely death at the age of 35 years.

- 16 WHITE, ROBERT M. A Summary of Present Research in Army Anthropometry. (Paper presented at the 19th annual meeting, American Association of Physical Anthropologists, Boston, Mass., April 1950). American Journal of Physical Anthropology, N.S. Vol. 8, No. 2, 272, June, 1950.

Abstract: Present research in Army anthropometry is summarized and some of the methods currently in use are indicated. Data available for investigation consist of measurements on over 100,000 men and 9,000 women, obtained during an anthropometric survey of Army personnel in 1946, as well as several smaller series measured subsequently. Since one of the primary responsibilities of the Office of the Quartermaster General is to clothe Army men and women, applications of anthropometric data to clothing problems have received first consideration. However, the Army program of research in physical anthropology may be considered to include both basic research and practical applications. Various problems such as age changes, and physical changes resulting from the military environment are being investigated. Since the aim of the Quartermaster Corps with respect to clothing is to fit the Army population with the best possible clothing in a minimum number of sizes, requiring the least amount of alterations, the applications of anthropometry to studies of clothing sizes, size systems, and tariffs are particularly useful. Applications of anthropometry to clothing consist of relating body dimensions to clothing sizes. This has necessitated a metric definition of the Army population, together with the establishment of frequency distribution curves for various body measurements. Practical applications of anthropometry and statistics are thus possible in the essentially artistic field of clothing.

- 17 HOOTON, EARNEST A., FREDERICK L. STAGG, NATALIE B. STODDARD, and EMMA H. ROBBINS. Handbook of Body Types in the United States Army (White Males). Volume I — Description of Types; Volume II — Plates. Contract Report (Contract W44-109-qm-2241), Department of Anthropology, Harvard University, Cambridge, Mass., January, 1951. Volume I — 311 pages; Volume II — 97 pages

This manual of body types in the United States Army is based upon the study of some 39,376 White male separatees measured and photographed in 1946 at six separation centers by anthropometric teams under the direction of the late Dr. Francis E. Randall, then Chief Anthropologist, Research and Development Branch, Office of the Quartermaster General. More than 100,000 men were measured; nearly 50,000 were photographed in three positions for the determination of body build type.

The classification of body types from photographs and measurements and the relationships of body types to various classes of information secured on each individual were undertaken by the Laboratory of the Department of Anthropology at Harvard University.

The first report of the Laboratory was submitted in September 1948 (Body Build in Relation to Military Function in the United States Army). This report dealt with the total distribution of body types in the sample of some 40,000 soldiers and the relation of body build to age, length of service, birthplace, national extraction, rank, military unit, military specialty, civilian occupation, education, marital status, and religious affiliation. The material was classified into types fit for combat duty and those fitted for service duties on the basis of the actual findings of excesses and deficiencies of the various types in categories of military function. In addition to White males, a series of some 3,000 Negro male separatees was similarly studied and figured in the report.

The second report of the Laboratory of Anthropology was submitted in October 1949 (Measurements of Body Build in a Sample of the United States Army). This report was concerned mainly with the statistical elaboration of the measurements of each body type sufficiently represented in the sample. Comparisons of the metric characters of the numerous body types were made, and corresponding body types in Negroes and Whites were discussed with the objective of clarifying racial differences.

To this end, the method of procedure in body typing has first been described. Then some 44 different body types are delineated in outline form with specific statements regarding body relief, fat covering, and the prominence of superficial muscles for each of the four main regions used in determining the body type.



In order to facilitate the study of the descriptive outline of each type with reference to the illustration of that and other types, the album of plates is bound separately from the text. Again, each type selected is reproduced twice, forming two separate series of plates. The first series starts with the lowest value (grade 1) of the first component (fat) and illustrates the types in order of increases in the second component. Then the second and subsequent grades of the first component are shown in the same order. In the second series, the photographs are arranged by the second component (bone and muscle development) in sequence of increases in the first component. Thus, the reader can compare the body types in two ways.

- 18 RANDALL, FRANCIS E., ELLA H. MUNRO, and ROBERT M. WHITE. Anthropometry of the Foot (U. S. Army White Male). Environmental Protection Section Report No. 172, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., January, 1951. 25 pages (AD 103 423)

The purpose of this report is to provide data on the interrelationships of dimensions of the U. S. Army White male foot for use by designers of Army lasts and footwear.

Data obtained during an anthropometric survey of the feet of 5575 Army White men are available in a report published in 1946 by the Armored Medical Research Laboratory, Fort Knox, Kentucky. Although the original report contains many useful data, the interpretations thereof do not permit direct application by designers of lasts and shoes for the Army. In order to provide greater detail and also more directly applicable information, an intensive analysis of the original Fort Knox data has been carried out.

The present practice of sizing and fitting shoes on the basis of foot length and ball breadth horizontal is not the best method available from a statistical point of view. A better method would be the use of ball length and ball girth dimensions, which most accurately control the fit of the shoe because of closer interrelationships with other critical dimensions of the foot. Reference data are provided in the form of tables and a nomograph for application of these relationships in the construction of lasts and shoes.

The general conclusion reached is that the dimensions of the foot which are closely related to the two basic dimensions, ball length and ball girth, are easily accommodated, whereas those poorly related cannot be accommodated by adjustment and, therefore, must be provided for in the design of the shoe. Dimensions which probably are critical in the proper fit of shoes, and which show low correlations with ball length and ball girth, namely, the dorsal and plantar arch heights, foot flare, and angular orientation of the heads of metatarsals, may be expected to occur with almost as much variation for any one size as they occur in all feet. Thus, in order to obtain shoes which will fit properly, it will be necessary to construct them in such a manner as to provide for a considerable amount of independent variation in most of the dimensions studied.

The results of this analysis provide a scientific basis for re-analysis of lasting practices.

- 19 WHITE, ROBERT M., and GERALD WINSTON. A Nine-Size System for Functional Clothing. Environmental Protection Section Special Report No. 50, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., April, 1951. 16 pages

Several alternative proposals for a nine-size system of cold-weather functional clothing have been evaluated with reference to available stature and chest circumference measurements of a large series of U. S. Army men. This investigation resulted in the development of a nine-size system which reflects the relationships indicated by body measurements and at the same time provides adequate coverage for the military population.



- 20 NEWMAN, RUSSELL W. Cranial Changes in a Sequential Skeletal Series. (Paper presented at the 20th annual meeting, American Association of Physical Anthropologists, Ann Arbor, Mich., March, 1951). American Journal of Physical Anthropology, N.S. Vol. 9, No. 2, 237, June, 1951.

Abstract: Comparisons of cranial measurements and indices of adult males from three archaeological horizons of Central California are illustrated by means of histograms. The visual analysis gained by this method gives insight into trends from horizon to horizon that are difficult to detect by the standard statistical analysis. It is concluded from an inspection of trends that the maximum change occurred between the first two of the three sequential time periods, a conclusion not apparent in the tabulated statistics of the same material.

- 21 WHITE, ROBERT M. Anthropometry and Clothing Sizing. (Paper presented at the 20th annual meeting, American Association of Physical Anthropologists, Ann Arbor, Mich., March, 1951). American Journal of Physical Anthropology, N.S. Vol. 9, No. 2, 242, June, 1951.

Abstract: There are four main fields in which the techniques and procedures of physical anthropology may be utilized in connection with military problems. Anthropometric data may be used in developmental work on military clothing and equipment, in investigations of body types in the military population, in identification of war dead, and in the development of prosthetic devices for war casualties. In The Army program of research in physical anthropology, anthropometric data have been used primarily in work on military clothing.

The development of a theoretical system of sizes for a functional jacket may be used as an example of the applications of anthropometric data in this type of work. Stature and chest circumference are selected as the controlling dimensions. Basic reference data are in the form of a bivariate chart showing the distribution of values of these two dimensions in the military population.

With assumed tolerances of three inches in each size, a size system of 25 sizes will be necessary to accommodate 15-inch ranges of stature and chest circumference in the military population. The number of sizes may be reduced to 16 or 15 by increasing tolerances in each size.

The correct location of the size system with respect to the distribution of body measurements in the population is determined by the ranges of stature and chest circumference to be covered, together with the relationship between the two dimensions. The result is a system of nine sizes which fulfills the basic requirement of maximum coverage of the population with a minimum number of sizes.

- 22 NEWMAN, RUSSELL W. Changes in Body Dimensions During Basic Training in Relation to Clothing Sizes. Environmental Protection Section Report No. 176, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., August, 1951. 27 pages (AD 148 845)

This study was initiated to investigate body dimension changes which take place in young men subjected to a rigorous military environment for the first time. These changes, as defined in terms of nude body measurements, have been analyzed in relation to clothing requirements for these men during the course of their basic training.

Five girth dimensions, waist, seat (hip girth), chest, shoulder, and neck, showed the greatest amount of change and were analyzed in detail. It has been shown that a sizable percentage of men change their girth dimensions sufficiently during basic training to require alterations on garments sized to their pre-training girths. These changes were shown to be largely assignable to men who were either small or large, and each group showed a definite trend in opposite directions. The small men tended to gain and the large men tended to lose. Fortunately, this allowed for a statistical analysis which differentiated and predicted girth changes with a reasonable degree of accuracy.

The most logical approach to the problem of sizing men entering the Army is to predict girth changes by means of data collected on men undergoing basic training and allow for these changes in the initial fitting. The limitations of such data were discussed, but it was evident that for all their limitations they represented an anthropometric estimate that should be preferable to not taking possible changes into account.



- 23 NEWMAN, RUSSELL W., and ROBERT M. WHITE. Reference Anthropometry of Army Men. Environmental Protection Section Report No. 180, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., September, 1951. 176 pages (AD 149 451) (Oversize format)

The purpose of this report is to provide data on the anthropometry of U. S. Army White males for use by the designers of equipment and clothing intended for men in the Army.

Eighty-seven regression tables and seventy-eight bivariate charts have been prepared to indicate a wide variety of interrelationship of pairs of dimensions which exist for a sample population of men in the Army. These data will serve as a guide to the designers of equipment for use by Army men.

- 24 RANDALL, FRANCIS E., and MELVYN J. BAER; edited and revised by RUSSELL W. NEWMAN and ROBERT M. WHITE. Survey of Body Size of Army Personnel, Male and Female — Methodology. Environmental Protection Branch Report No. 122 (Revised), U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., October, 1951. 48 pages (AD 149 458) Originally published July, 1947

Descriptions and illustrations of anthropometric measurements collected on 105,062 men at six Army separation centers in 1946 are presented. The anthropometric survey was carried out to collect data on body dimensions of Army personnel for use in research on items of Quartermaster clothing and equipment. The data collected in this survey were considered necessary in the establishment of specifications on the body size of male military personnel, both in relation to clothing sizing and tariffing, and in the definition of workspace requirements.

This report was initially issued in July, 1947. The demand for it exhausted the supply; therefore, it was revised and reissued to coincide with the publication of Environmental Protection Section Report No. 180, Reference Anthropometry of Army Men. The changes consisted of the addition of one figure and expansion of the glossary. The photographs illustrating the measurements are the same, but definitions of some of the measurements have been clarified.

- 25 TROTTER, MILDRED, and GOLDINE C. GLEESER. Trends in Stature of American Whites and Negroes Born Between 1840 and 1924. (Contract DA44-109-qm-199, Department of Anatomy, Washington University, St. Louis, Mo.). American Journal of Physical Anthropology, N.S. Vol. 9, No. 4, 427-440, December, 1951.

The average stature of an adult population may not remain stable from generation to generation. Environmental conditions, genetic composition and natural selection are among the many factors which can contribute to change. These factors have been grouped under the general term of secular factor as differentiated from the ageing factor which produces changes in stature during the life cycles of the individuals comprising the population. In studies of the effect of the secular factor on maximum stature, at least three methods, each with variations, have been applied. The average statures of living subjects at various age levels have been obtained and the trend, if any, observed; unfortunately, by this method, the effects of both the secular and ageing factors are included. Records of average statures of previous generations have been compared with those of more recent or of present generations; by this technique the completeness of data of the previous generations cannot be controlled, and differences in the methods of taking the measurements may be unduly large. Finally, stature measurements of groups of school children of given ages in two or more successive periods have been compared; such data generally do not cover a very long time span. The purpose of the present study is to offer supplementary data bearing on the question of the effect of the secular factor on maximum stature of individuals born in successive decades. To this end, the length of long bones, a measure which is closely related to maximum stature, is introduced as additional evidence.

Trends in stature have been studied in individuals (both sexes of American Whites and Negroes) born between 1840 and 1924. Two sources are represented: the Terry Collection with individuals born chiefly in the nineteenth century, and military personnel born in the twentieth century. In addition, the combined lengths of femur and tibia have been examined in relation to successive time periods.

There obtains a relatively constant average stature devoid of trend for all four groups born between 1840 and 1895. There is a tendency for the Negroes (both males and females) to increase slightly in stature from 1895 to 1905. A significant increase in male stature is present in individuals born between 1905 and 1924 (data for Negroes are less conclusive than for Whites because of the smaller sample). Stature trend in American White and Negro populations thus presents minor fluctuations in the nineteenth century followed by a rapid increase in the twentieth century. This total picture of stature trend over a period of 85 consecutive years refutes the hypothesis that stature increases progressively from decade to decade.



The length of the long bones in all four groups showed fluctuations consistent with stature changes in the corresponding time periods. Thus, the feasibility of utilizing such measures in the study of stature trends is demonstrated and even recommended since the effect of the ageing factor and the need for recorded stature of the subject are eliminated. The scope of accessible data for studies of stature trend is enlarged by means of documented skeletal collections.

- 26 MUNRO, ELLA H. Preparation of Anthropometric Nomographs. Environmental Protection Branch Report No. 184, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., February, 1952. 21 pages (AD 199 487)

The purpose of this report is to provide simple sources of reference of anthropometric data for use by designers of clothing and other personal equipment.

Seven analyses of Army populations were made in order to present the interrelationships between selected bodily dimensions and two independent dimensions, varying according to the analysis. Each analysis has resulted in a nomograph which is the graphic representation of the interrelationships.

Use of these nomographs will be of aid to the designers and developers of clothing and equipment used by Army personnel, both male and female.

- 27 WHITE, ROBERT M. Some Applications of Physical Anthropology. *Journal of the Washington Academy of Sciences*, Vol. 42, No. 3, 65-71, March, 1952. Also published as Chapter 10 in: THOMAS W. McKERN (editor) **Reading in Physical Anthropology** (second edition), Prentice-Hall, Inc., Englewood Cliffs, N. J., 1972. (Library of Congress Catalog Card No. 75-166981)

Just as some cultural and social anthropologists have adapted their particular fields to contemporary problems, so have some physical anthropologists drawn from their techniques and developed methods by which many problems of every-day living which involve dimensions of the human being may be subjected to scientific analysis and solved in an objective manner. However, the physical anthropologist encounters large numbers of "experts" when he approaches any of the numerous problems he may solve or help to solve.

Clothing, furniture, and automobiles are all familiar items, but it comes somewhat as a shock to us to find that so little consideration has been given to us, as people, in the design of these articles. One of the greatest handicaps in reaching a mutual understanding with the designer or engineer is the necessary use of statistical knowledge in explaining the problem. Two factors may explain this condition. The first, and fundamentally the most important, is the lack of static and dynamic anthropometric data. Allied with this, although necessarily following it in demand, is the lack of statistical knowledge required to obtain proper application. The second, and of equal practical importance, is the universal attitude that the accommodation of the human being is a factor in the general field of competition. Whole industries are willing to standardize sizes of fittings, but the perfectly simple concept of standardization of accommodation for human beings has not yet been accepted.

When the physical anthropologist carefully measures large series of people, develops objective analyses, and proposes results to be introduced into the design of all types of personal equipment or of equipment which requires accommodation of the human being, only part of his work is done. Two parts remain. He must educate the designers in his way of thinking, and then he must collaborate with the designers in setting up experiments which will convert the anthropometric requirements into terms which will be familiar to them. It is the goal of the investigator to provide information for the designer as to the requirements of accommodation. It is the goal of the designer to meet these requirements. Finally, it is the objective of both to obtain the optimum compromise at the minimum cost.

Thus, in the field of applied physical anthropology, the physical anthropologist occupies three successive positions. Initially, he is an anthropometrist in collecting the metric data. Secondly, he is a statistician in preparing the "specifications" which describe the requirements. Finally, he is an applied physical anthropologist,



analyzing the problem of the designer insofar as it relates to human bodily dimensions, and in providing for the designer, in concrete practical terms understandable to the designer, the measure of fulfillment of the requirements by the designer. Many times this last role permits the anthropologist, through his analysis, to suggest revisions in the original design which will improve its efficiency materially and often reduce its cost.

- 28 NEWMAN, RUSSELL W. Age Changes in Body Build. American Journal of Physical Anthropology, N.S. Vol. 10, No. 1, 75-90, March, 1952.

Before somatotyping can be effectively utilized for personnel selection or like purposes, the question of the permanence of the somatotype must be investigated. The original source of data on this system of body build analysis considered the problem briefly and concluded that the somatotype was permanent in the normal male. This concept has been adopted by followers of the system. Dupertuis says: "one of the premises of the constitutional anthropologist is that the components of an individual's somatotype remain constant, at least after skeletal growth is completed." Everyone will agree that the final test of immutability of the somatotype can only be made by following a large number of subjects for many years. Results of this type of investigation have not yet been published, and it may be many years before sufficient material can be collected. In the interim there is another approach, admittedly not as precise, which can give valuable data. This involves a cross-sectional study of a large number of individuals of varying ages. This paper attempts to explore the question of body build permanence through a study of such age groups.

The problem of stability in body build has been investigated by examining a series of some 40,000 individuals photographed by the U. S. Army and typed at Harvard University. The age groups from 18 through 35 years have been analyzed for: percentage of occurrence for each rating, mean component scores, summation of component scores, product-moment correlation coefficients, and partial correlation coefficients on a year by year basis.

These analyses indicate that definite although limited changes are associated with age in this Army series. The 1st and 2nd components increase with age while the 3rd component decreases. The correlation between the 1st and 2nd components and 1st and 3rd components increase with age but the 2nd and 3rd components retain the same magnitude of association.

Similar values of central tendency and statistical association have been compared for White, Negroid, and Mongoloid series typed by the Hooton system and White and Mongoloid series typed by the Sheldon system. The values show large differences between investigators that pose problems of comparability in technique.

- 29 WHITE, ROBERT M. Applied Physical Anthropology. American Journal of Physical Anthropology, N.S. Vol. 10, No. 2, 193-199, June, 1952.

Scientific research in general consists of two main efforts, not always clear and not necessarily mutually exclusive, but nevertheless usually distinguishable. The first includes investigations which primarily add to our body of knowledge. These are largely the result of our intellectual curiosity. The second comprises studies oriented toward useful or practical applications. These are the result of our desire for improvement of one sort or another. This situation is particularly true in anthropology — the study of man.

In some scientific disciplines such as mathematics, physics, chemistry, or engineering, careful distinctions are made between pure and applied fields. It does not seem necessary, however, to delimit separate categories of theoretical and practical work in physical anthropology, since, most, if not all types of research in physical anthropology have, or at least should have, ultimate applications of some sort.

Workers in applied physical anthropology need not confine themselves only to immediate problems. Thus the data utilized in the solution of practical problems should also be explored for possible contributions toward theoretical problems. Some of the methods and techniques developed during the course of practical investigations may have wider utilization. In this way, applied physical anthropology can fulfill a useful and profitable function in the field of anthropology as a whole.

Applied physical anthropology, then, is an approach in which attention is focussed upon the solution of practical problems. It is varied in scope and often utilizes modifications or adaptations of conventional techniques. It is a point of view which permits expansion in the general field of anthropology, as well as collaboration with workers in other fields of endeavor.



- 30 NEWMAN, RUSSELL W. Measurement of Body Fat in Stress Situations. Environmental Protection Branch Report No. 193, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., November, 1952. 22 pages (AD 2579)

This study was initiated to investigate the use of body fat measurement by the skin-fold technique in environmental stress situations. Two experiments, one involving a prolonged heat exposure, and the other concerned with the consumption of a survival ration furnished the opportunities to collect the data.

Data on body weight, body fat, caloric intake, and water intake were presented and analyzed for each experiment. Mean values were used for five men in the heat study and for ten men in the ration study. Data on body fat in the heat study indicated that this measure was influenced by the extreme heat (120°F) in which the subjects were placed. The high fat values obtained in the heat were presumably caused by a peripheral vasodilatation which appeared within the initial four hours of exposure. Body weight was influenced by the large quantities of water required in the heat and probably by the small water intake available with the survival ration.

In the absence of heat stress, the skin-fold method for estimating body fat gave excellent results; the simplicity of instrumentation and ease of collecting the data make this method ideal for investigating military groups under laboratory or field conditions. The analyses presented in this study indicated that weight loss recorded for the test subjects in both experiments can be closely accounted for in terms of the adipose and protein tissue losses.

- 31 NEWMAN, RUSSELL W. The Assessment of Military Personnel by 1912 Height-Weight Standards. Environmental Protection Branch Report No. 194, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., November, 1952. 22 pages (AD 2580)

This study was made to establish and compare relative weights in three Army series: White male separatees measured in 1946, Negroid male separatees measured in 1946, and White male inductees measured in 1946 and 1949, with the height-weight table established by the medico-acturial mortality investigation of 1909-1912, utilized as the standard in this assessment.

The three Army series were uniformly higher than the 1912 medico-actuarial standards in weight. The White and Negroid separatees demonstrated an unexplained decrease in the average relative weight with age. The White inductees did not show this decrease over the limited available age range. The largest Army group, White male separatees, was compared to two other standards, a European standard which proved unsatisfactory because age was not taken into account, and a study of civilians in 1940 by the Equitable Life Assurance Society. The Equitable Life data showed overall average weights that more nearly approached the Army data but a curious discrepancy in tall-statured men occurred.

The 1912 medico-actuarial data appeared obsolete when a modern military series was judged by these standards. The civilian population of the 1940's, measured at the time of induction into the Army, appeared to lie approximately midway between the military and 1912 series. Some unidentified military factor caused a differential addition of weight with age not found in the civilian data.

- 32 TROTTER, MILDRED, and GOLDINE C. GLEESER. Estimation of Stature from Long Bones of American Whites and Negroes. (Contract DA44-109-qm-199, Department of Anatomy, Washington University, St. Louis, Mo.) American Journal of Physical Anthropology, N.S. Vol. 10, No. 4, 463-514, December, 1952.

The estimation of stature from length of long bones of the free limbs is often an important contribution to the identification of unknown human remains. The need for identification was realized, perhaps more keenly than ever before, during the United States Repatriation Program. This program was established by an Act of Congress in 1944. It included the identification (when possible) of unknown war casualties and was assigned to the American Graves Registration Service under the Army Quartermaster Corps. Identification laboratories were established in suitable parts of the world and the aid of physical anthropologists was enlisted.

The American Graves Registration Service has obligations which have stimulated interest in improvement of methods for identification of skeletal remains. Coincidentally, the ideal combination of data for the determination of formulae for estimation of stature from long bone lengths became available. These data are from American White and Negro military personnel and comprise measurements of stature during life and measurements of long bones of the free limbs after death. The Terry Anatomical collection has been introduced into this study in order that formulae from a very different source might be provided; that these two sets of formulae, after adjustment for differences in age and in measurements of living and cadaver stature, might be tested against each other; and, that formulae for females of both races might be evolved.

Only subjects who were at least 18 years of age when stature was measured have afforded data for the equations of stature estimation. All six long bones were measured for maximum length; in addition, the bicondylar length of the femur and the length between the articulating surfaces of the tibia were taken. The average length of right and left bones of any given pair was utilized in the statistics because of the greater reliability of an average. Furthermore, the differences in length between the bones of the two sides are small and when the bone of only one side is available an adjustment in an equation based on the average is not necessary.

Regression equations for estimation of stature from the length of each long bone and from the lengths of multiple bones were determined for each group of subjects available from the two sources. The single bone equations are almost identical for the two lengths of femur and for the two lengths of tibia; thus only the maximum length of each bone was utilized in the multiple bone equations. Intercorrelations among the lengths of the six long bones are very high, particularly between radius and ulna and between tibia and fibula, so the ulna and fibula were omitted in the multiple bone equations. In both single and multiple equations the bones of the lower limb result in estimations of stature with a smaller standard error than do the bones of the upper limb.



Equations for estimation of long bone lengths (humerus, radius, ulna, tibia, fibula) from the femur are presented for Whites and Negroes of both sexes.

The increase in cadaver stature (measured according to the method of Terry) over that of living stature is estimated to be 2.5 cm. When this correction is made and loss of stature from ageing is taken into account, the equations for estimation of stature of males based on data from the Terry Collection and from the military personnel are shown to be in substantial agreement. It seemed reasonable to assume that equations based on females of the Terry Collection, with corresponding adjustments are likewise applicable to the American population of White and Negro females.

Thus equations (determined from both single and multiple bones) for estimation of living stature of American Whites and Negroes of both sexes are presented. These equations are applicable to maximum lengths of long bones which are dry and without cartilage. The resultant estimates are of maximum living stature and can be reduced by the amount of 0.06 cm (age in years - 30) to cover the effects of ageing. A test of the equations for White males by application to a different sample of American White military personnel gives results well within the expected range of accuracy. Comparison of statures estimated for this new sample according to equations (involving femur and humerus) developed in this study with those of other investigators demonstrates that the present formulae give the most accurate estimates of stature. Another comparison involving the application of each investigator's equation (based on the femur) to every other sample of like sex demonstrates the advantage of the age factor in the equation and also the need for an adjustment when cadaver stature (as measured by Todd) is utilized as a measurement of living stature.

The Negroes of both sexes have significantly longer bones of the free limbs than do the White groups; the Negroes also have longer forearm and leg bones relative to the arm and thigh bones than do Whites; and, in general the Negroes have longer bones of the limbs relative to their stature. These comparisons, pointed toward the relationship of the variables, indicate the necessity of independent equations for estimation of stature for each sex of the White and Negro races.

- 33 BAKER, PAUL T. The Effects of a Hot-Dry Climate on Gross Morphology. Environmental Protection Branch Report No. 197, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., January, 1953. 25 pages (AD 3354)

This study represents an effort to discover what the effects of a hot-dry climate are on gross body structure, to find the changes, if any, in gross body structure by multiple techniques, and to relate them to the general military problem of the effects of climatological and other physical stresses on the human body.

Only weight and measures derived from weight of the measures taken on a group of Army personnel on temporary duty at Yuma Test Station, Arizona, did not change. The circumferences of mid-arm, shoulder, chest, and waist all showed a loss during the first three to four weeks. Shoulder and arm circumferences lost more than the others. The measures of arm, chest, and waist skin-folds showed a considerable loss as did the derived measure of total body fat. An inspection of the change trends showed that there were three different loss patterns; one, formed by the circumferences; two, formed by the waist and chest skin-folds; and three, formed by the arm skin-fold. When the group was broken down into subgroups it was found that Negroids were significantly different than Whites in the measures taken. Division by amount of fat at the first measure also gave two significantly different groups. Loss patterns for these subgroups indicated that each one lost in a different manner than the other. Although all of them lost to some extent, the Negroids showed a smaller loss in most of the measures than the Whites did. The fat men lost more in all the measures than the thin men; however, because the fat men had much more soft tissue to begin with, these losses were not as great relatively as those of the thin men. A breakdown of the group by occupation did not show groups which were different to begin with; neither did any of these subgroups change in a manner which was different from the total group. Cluster analysis indicated that the measures taken represented three groups of measures which were highly related within themselves but not highly related to each other. These three groups were the same ones found by the inspection of the loss trends. From the discreteness of these measurement groups it was hypothesized that the extremities as represented by the arm showed a greater loss in circumferences and fat than the torso.

- 34 NEWMAN, RUSSELL W. Clothing Size Requirements for Korean Military Personnel. Environmental Protection Branch Report No. 206, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., April, 1953. 15 pages (AD 11 851)

This study on bodily dimensions of approximately 2450 Koreans was undertaken to provide clothing design and tariff information applicable to Korean personnel who might be supplied with U. S. Army clothing and equipment. The Korean personnel differed principally from U. S. soldiers in the combination of bodily proportions which would be fitted in clothing. They were characterized by small girths, long bodies, and short extremities. The U. S. clothing is sized to fit popular combinations of length and girth. Korean tariffs for upper and lower body garments were calculated by superimposing U. S. garment sizes on two-dimensional analyses of critical fitting dimensions. It was found that the present sizes of U. S. Army upper body functional clothing gave inadequate coverage for the Korean population, because no X-Long lengths are procured, and because of a deficiency in the number of Long lengths now provided. The U. S. functional lower body garment sizes were also inadequate because of no X-Short lengths and a deficiency in the number of Short lengths. Little or no Korean requirements were found for approximately half of the present U. S. sizes. Tariff requirements for headgear, handgear, and footwear for Korean personnel also were analyzed.



- 35 NEWMAN, RUSSELL W., and GERALD WINSTON. Comparison of Ten Anthropometric and Tailoring Measures on the Same Men. Environmental Protection Branch Report No. 210, U. S. Army Quartermaster Climatic Research Laboratory, Lawrence, Mass., June, 1953. 13 pages (AD 20 962)

This study was undertaken to determine the relationship between two types of measurements, i.e., anthropometric and tailoring. The information could then be applied to the large amount of anthropometric data available on military personnel and would facilitate a translation of anthropometric data into meaningful pattern measurements.

Data on ten bodily measurements: neck, shoulder, chest, waist, and hip (seat) circumferences, sleeve length, scye depth, inside arm length, outseam, and inseam were presented and analyzed for the relationship between the two types of measurements on 42 men. The relative reliability of the two techniques was assessed and was found to be roughly similar; the relationships appeared sufficiently consistent to warrant translation from one technique to the other without undue loss of accuracy. Methods for conversion from one type of measurement to the other were presented in several forms if appropriate to individual situations.

- 36 NEWMAN, RUSSEL W. Speculation on the Significance of Muscle-Bone Relationship in Terms of Human Evolution. American Journal of Physical Anthropology, N.S. Vol. 11, No. 2, 233—235, June, 1953.

The ultimate aim of human paleontology has been to extrapolate from the fragmentary osseous remains of man's ancestors a complete and functional understanding of the animals. Washburn has pointed out the need for extreme care and a sound knowledge of the intimate relationships between bones or portions of bones and the soft tissues which clothe them before this reasonably can be accomplished. This brief communication has as its purpose to point out another area where our information is deficient and to appeal for research designed further to elucidate the general problem of muscle-bone relationships in our conceptual scheme of man's evolution.

- 37 BAKER, PAUL T. Comparison of Negroid and White Fat Changes Under Desert Heat Stress. (Paper presented at the 22nd annual meeting, American Association of Physical Anthropologists, Philadelphia, Pa., December, 1952). American Journal of Physical Anthropology, N.S. Vol. 11, No. 2, 260, June, 1953.

Abstract: In June, 1952, a group of 21 Negroid and 45 White soldiers were measured in Virginia, prior to their departure for a 6-week tour of duty in the Arizona desert. They were subsequently measured at weekly intervals. Measurements used were: weight; mid-arm, shoulder, chest and waist circumferences; subcutaneous fat of the upper arm, chest and waist (by skinfold calipers); and total percentage of fat in the body. In pre-desert measurements, both groups had the same mean stature and weight. The Whites had significantly larger chest and waist circumferences and twice the amount of fat. By the end of the first week in the desert, the Whites had gained in all torso measurements and in total body fat. After this time, there was a steady decrease in torso circumference measurements and in the amount of torso fat. Arm circumference and arm fat decreased continuously, without the initial first-week rise. Negroid measurements did not display the same increase in fat and circumference during the first week. Instead, a steady loss in fat was recorded for the full test period, while changes in circumference were erratic. Final measurements showed that Negroids lost 25% of their original body fat while Whites lost 13%. Contrary to expectations, weight losses did not accompany body changes in either racial group.



- 38 WEDGEWOOD, RALPH J., and RUSSELL W. NEWMAN. Measurement of Body Fat by Air Displacement. (Paper presented at the 22nd annual meeting, American Association of Physical Anthropologists, Philadelphia, Pa., December, 1952). American Journal of Physical Anthropology, N.S. Vol. 11, No. 2, 260, June, 1953.

Abstract: The most practical and accurate method of measuring total body fat is by assessment of specific gravity. All direct specific gravity data are at present obtained through total immersion of the subjects in water. This technique requires cumbersome and non-portable apparatus, a period of subject training before reliable results can be obtained, a careful measurement of the residual air in the lungs, and is inapplicable to the very young or the infirm.

A method which avoids or minimizes the disadvantages of water immersion is that of substituting air displacement for water displacement. A short motion picture showing the apparatus being used on two subjects was presented. The general theory of the measurement of air displacement by electrical means, the methods of calibrating the volumetric cylinder, calculation of body fat on two subjects, and comparison with body fat obtained by skin-fold measurements were shown.

- 39 NEWMAN, RUSSELL W. Model and Size Data for the Design of Men's Clothing. Environmental Protection Division Report No. 217, U. S. Army Natick Quartermaster Research and Development Laboratory, Lawrence, Mass., July, 1953. 18 pages (AD 21 553)

This study presents average data on bodily dimensions of approximately 25,000 U. S. Army soldiers. This series is successively divided into subgroups on the basis of size (chest circumference), model (drop or chest circumference minus waist circumference), and length (stature). Mean values on size groups and models within size groups are presented in tabular and graphic form to facilitate interpretation. Length groups within the models and sizes are given in tabular form only. The percentage of occurrence of the model groups, i.e., 25 percent of Slender (seven to ten inches of drop), 62 percent Normal (four to seven inches of drop), 10 percent Portly (1½ to four inches of drop), and 1 percent Stout (zero to 1½ inches of drop) indicates that a definite requirement exists for their use in men's service or semidress uniforms. The atypical groups, Slender and Portly, are found with almost equal frequency in all chest size groups. It is recommended that the data presented here be considered in any proposed major revision of the U. S. Army men's service uniform.

- 40 NEWMAN, RUSSELL W. Applied Anthropometry. In: **Anthropology Today**, an Encyclopedic Inventory, prepared under the chairmanship of A. L. KROEBER, Chicago University Press, Chicago, Ill., 1953. (pp. 741-759)

Summary not available.



- 41 NEWMAN, RUSSELL W. Skinfold Interrelationships in Young Males. (Paper presented at the 23rd annual meeting, American Association of Physical Anthropologists, Yellow Springs, Ohio, March, 1954). American Journal of Physical Anthropology, N.S. Vol. 12, No. 2, 296, June, 1954.

Abstract: Skin-fold thickness used in the calculation of body-fat has not been measured on a single homogeneous sample of sufficient size to allow detailed comparisons of changes with increased obesity. The series reported here, consisting of approximately 1700 White and 300 Negroid males, permit such comparisons as well as indirect methods of assessing the applicability of calculating body-fat on Negroid males by use of relationships established on Whites.

The racial analyses clearly show a deficiency in subcutaneous fat in Negroids when compared to Whites of a similar age group. The skin-fold site on the chest and arm appear most distinctive between these groups, but the Negroids are sufficiently similar to Whites in skin-fold relationships to warrant the use of a common formula for converting skin-folds to percent body-fat.

Analyses of five skin-fold thicknesses on the body indicate that these areas do not show parallel or even linear changes in relation to increasing obesity. This phenomenon raises a question concerning the advisability of using a single linear multiple regression equation in calculating body-fat.

- 42 DANIELS, FARRINGTON, Jr., and PAUL T. BAKER. Subcutaneous Fat and Body Cooling of Men in Air at 15°C. Paper presented at a meeting of the American Physiological Society, Madison, Wis., September, 1954.

Abstract not available.

- 43 BAKER, PAUL T. Relationship of Desert Heat Stress to Gross Morphology. Environmental Protection Division Technical Report EP-7, U. S. Army Quartermaster Research and Development Center, Natick, Mass., March, 1955. 27 pages (AD 57 392)

A study was made of the effect of a desert climate on gross morphology. A total of 83 men were measured before reporting for duty and at intervals during duty at Yuma Test Station in Arizona, in 1953. Of these, 29 were X-rayed before and after this duty for a more careful analysis of body composition. It was found that there was a fat loss without significant body weight change. Roentgenographic plates of the arm and thigh indicated a fat loss and muscle increase. This finding was the same as was noted for groups performing similar tasks at Yuma, Arizona in 1952.

Also, the relationship of gross morphology to the ability of the individual to resist heat stress was studied in three groups totaling 50 men. Individual resistance to heat stress was measured by walking the men for one hour at a constant pace and then recording their sweat loss, rectal temperature, and pulse rates. It was found that the size of lean body mass was highly correlated to amount of sweat loss, and that percent of fat had a fair order positive correlation to sweat loss and rectal temperature, but the relationship of percent fat to pulse rate was not conclusively established. Although stature was related to sweat loss and pulse rate, it was found to be important only as a variable in body attenuation. The best possible estimation of sweat loss was gained by a multiple correlation of lean body mass, percent fat, and stature. Even though surface area is important in heat regulation, the material indicated it was not a good standard of reference. It was also found that the use of stature and weight as separate entities gave better prediction of sweat loss than a combination of these for an estimate of surface area. Increasing the stress level produced steeper slopes for the regressions of sweat loss to weight and rectal temperature to percent fat. This suggests that gross morphological factors become more important in the individual's ability to resist heat stress as the stress increases.



- 44 NEWMAN, RUSSELL W., and ELLA H. MUNRO. The Relation of Climate and Body Size in U. S. Males. *American Journal of Physical Anthropology*, N.S. Vol. 13, No. 2, 1-17, March, 1955.

The recent interest in the application of ecological rules to man has produced impressive evidence of association between elements of body size and temperature. The basic precepts of Bergmann's rule and its application have been fully covered elsewhere and need only to be summarized here. In brief, Bergmann's rule states that subspecies' body sizes increase in colder climates and decrease in warmer climates. This is related by Schreider to the physical principle that the ratio of heat-generating mass (body weight) to heat-eliminating mechanism (body surface area) varies from high ratios in colder climates to lower ratios in warmer temperatures.

An investigation of possible statistical relationships between climatic environment and body size in a sample of youthful, White, American males was carried out. The series, consisting of approximately 15,000 men measured at the time of their induction into the Army, was divided on the basis of state of birth into 48 groups, and average biological and environmental values for each state were correlated. Body weight and stature were measured on the men and surface area was calculated from these values. The average weight divided by the average surface area for each state was also used. Four measures of climatic environment, mean annual temperature, mean July noon "effective" temperature, mean July temperature, and mean January temperature, were analyzed with the measures of body size by the use of correlation coefficients, partial correlation coefficients, and multiple correlation coefficients.

The analysis indicated that there was a correlation which followed Bergmann's rule of larger weights, surface areas, and greater weight per unit of surface area in colder climates. In contrasting the different types of temperature data with the body size, it appeared that January temperatures were more closely correlated than the heat stress data or the mean annual temperature. The weight/surface area ratio showed little advantage over a simultaneous analysis of stature and weight by the multiple correlation technique.

Four possible casual factors for the temperature and body size relationships were examined. Regional distribution of groups with common European national extraction, unequal nutritional opportunities caused by economic factors, heat regulation through proportional changes in the heat-generating mass and heat-dissipating surface, and the stimulation of appetite and activity in cold were discussed; and the last chosen as most plausible with these data.

The study clearly indicated that association between body size and environmental conditions is not restricted to "primitive" groups. The causes for

the association (which can only be hazarded here) may not be the same between groups, but neither can the influence of environment on man's physical form over and above his cultural defenses be discounted. The conclusions of this paper are that Bergmann's rule of body size relationship with environmental conditions are valid in a United States population, and that this relationship is more highly correlated with January than annual or July temperatures. The reasons why must await further and probably experimental type studies.

- 45 NEWMAN, RUSSELL W. Skinfold Changes with Increasing Obesity in Young American Males. *Human Biology*, Vol. 27, No. 2, 53-64, May, 1955.

Two problems involving skin-fold measurements on a large series of young American men have been examined in this paper. The results cannot be considered definitive because no independent measure of average body density was available; the conclusions arrived at using the sum of the skin-folds can only be termed indicative.

An analysis of Negro and White skin-fold relationships by comparing correlation coefficients between skin-fold sites and average skin-fold values for increments of obesity showed small and not statistically significant differences between these racial groups. It was concluded that the present data do not show any reason why body fat on Negroes cannot be calculated from the published prediction equation based on White subjects. However, the comparison was limited by the scarcity of obese Negroes, and it is possible that the observed Negro deficiency of fat over the pectoral and triceps regions might become practically significant if very obese Negroes were compared to their white counter parts. This racial difference in the regional distribution of subcutaneous fat is an intriguing problem which should repay further investigation.

A graphic comparison of the various skin-fold sites in the combined series of 2,000 men for presumed increments of increasing obesity indicated a change in the proportional representation of the average site values between the lean and fat subjects. The anterior torso areas, chest and abdomen, showed a rise in relative importance with increasing obesity at the expense of the extremity areas; i.e., the arm and knee. This was interpreted to be at least partially the result of physical space limitations in the extremities. It may form a source of error in predicting fat on all men of a comparable age group with a single prediction equation.

This paper has only touched on a few of the interesting possibilities inherent in the skin-fold measurements of these 2,000 young men. Its major purpose was to validate, if possible, the calculation of body fat on the 361 Negroids for use in other analyses. It is believed that this has been accomplished, and a new and intriguing field of anthropometric investigation can be developed through the skin-fold measurement technique.



- 46 NEWMAN, RUSSELL W. The Relation of Climate and Body Composition in Young American Males. (Paper presented at the 24th annual meeting, American Association of Physical Anthropologists, Philadelphia, Pa., April, 1955). American Journal of Physical Anthropology, N.S. Vol. 13, No. 2, 386, June, 1955.

Abstract: The association of body size and shape with measures of the physical environment has been handicapped because the available measures of size and shape (total body weight and stature) are difficult to accept as indicators of functional homeothermic entities. The use of gross body weight as an indicator of the heat-producing mass of the body ignores the fact that at least two major bodily elements are subsumed by this value, the muscular tissue with accompanying fluids and the fat tissue. Data are presented which divide gross body weight on approximately 2000 young American White males into two fractions which are more meaningful in this association. Fat free weight is equated with the heat producing mass of the body and body fat calculated from skin-folds is considered as a heat conserving layer surrounding the fat free mass.

Correlation coefficients, partial correlation coefficients, and multiple correlation coefficients between the biological measures (fat free weight and body fat) and climatic data (mean annual, mean January, and mean July temperatures) showed higher values than was found with a much larger series using only weight and stature. Although the interpretation of the statistical relationships between climate and these elements of body composition may be changed by subsequent and more extensive data, it appears that two climatic elements are involved in the problem, body fat being inversely proportional to summer heat and fat free weight inversely proportional to winter cold.

- 47 BAKER, PAUL T. An Experimental Approach to the Effect of Climate on Man. (Paper presented at the 24th annual meeting, American Association of Physical Anthropologists, Philadelphia, Pa., April, 1955). American Journal of Physical Anthropology, N.S. Vol. 13, No. 2, 387, June, 1955.

Abstract: Anthropological thought concerning the effect of climate on evolution and race formation has gone through many fads. We still have very little fact. In such a situation, opinion rules supreme. By applying experimental procedures and utilizing physiological, psychological, and anthropological techniques, we are now in a position to do definitive research. Past research done in the desert and in cold chambers indicated that the heat and cold resistance of individuals is closely related to their body composition and configuration. We may also test for racial differences in heat and cold resistance. A study was conducted at Fort Lee, Virginia, to determine whether there is a difference between American Negro and White heat stress resistance. Forty-eight Whites and forty-eight Negroes were matched for body fat, fat free weight, and stature. These men were exposed to equal heat stress by having them hold a walking pace of 3½ miles per hour for one hour. Sweat loss, rectal temperature, and pulse rate were recorded. During the experimental period weather conditions were cooler than normal for Virginia in August. Rectal temperature was significantly lower for Negroes than Whites. Sweat loss and pulse rate differences were not statistically significant.

The results of this study can be considered as only indicative in that the heat stress was low. Even so, it exemplifies the potential of the approach. The instrumentation and technique is simple enough to apply in the field on native populations. If we had data on the heat and cold resistance of even a few world populations, we would have a solid basis on which to speculate about man's relationship to his climatological environment.

- 48 JEFFREY, THOMAS E., and L. L. THURSTONE. A Factorial Analysis of Foot Measurements. Contract Report (Contract DA44-109-qm-1125), The Psychometric Laboratory, University of North Carolina, Chapel Hill, N. C. Environmental Protection Division Technical Report EP-10, U. S. Army Quartermaster Research and Development Center, Natick, Mass., July, 1955. 30 pages (AD 66 971)

This report gives the results of a methodological study carried out for the purpose of investigating the nature of some of the critical factors determining the size of feet in Army personnel. Twenty-nine measures taken from the anthropometric data collected in the Fort Knox Foot Survey were factor analyzed.

Ten factors were extracted accounting for the intercorrelations between these 29 measures with relatively small residuals. The absolute size of the residual correlations after the extraction of the tenth factor was less than or equal to 0.06.

Eight of the ten rotated factors have been interpreted. This interpretation for each factor describes the nature of the underlying parameter responsible for the concomitant variation of the measures with large projections on the factor. Two factors were not interpreted.

The amount of the total variance for each measure accounted for by the ten factors varied from about 100 percent down to 11 percent. This indicates that at least one measurement (100 percent) shares all of its variance with one or more of the remaining 28 measures, and, consequently, could be relatively unimportant in the determination of shoe lasts. On the other hand, measures which share only 10 to 15 percent of their variance with other measures would have to be considered specifically in the proper fitting of shoes.



- 49 BAKER, PAUL T., ROBERT F. BYROM, FARRINGTON DANIELS, Jr., and ELLA H. MUNRO. Relationship Between Skinfold Thickness and Body cooling at 59°F. Environmental Protection Division Technical Report EP-14, U. S. Army Quartermaster Research and Development Center, Natick, Mass., July, 1955. 25 pages (AD 68 008)

This study was designed to test the relationship between body fat and body temperatures when men are subjected to a cool environment. Thirty-one men were exposed to an ambient temperature of 59°F (15°C) for two hours. They wore only shorts and were seated for the total period. Rectal and skin temperatures were recorded at 10-minute intervals.

It was found that fat, as measured by skin-fold calipers, bore a strong relationship to both rectal and skin temperatures. The greater the percent of fat in the body, the lower the skin temperatures. The correlations were closer between skin temperature and skinfold thickness in specific areas than between skin temperature and the calculated percent of fat in the body. The difference between one and 19 percent body fat made 5.9 degrees (F) difference in the minimum mean weight skin temperatures.

The correlation between minimum rectal temperature and percent of fat was high: the fattest men maintained near normal rectal temperatures, while the thinnest men had rectal temperatures 1.2°F lower. The examination of stature and fat-free weight correlations indicated that the primary relationship of fat to rectal temperature was modified by variations in body surface area.

The results of the study indicated that fat men, at least while inactive and wearing only shorts, maintain internal body temperature at a more nearly normal level than thin men, but fat men have lower skin temperatures. This can be interpreted as indicating that subcutaneous fat is acting as an effective insulator.

- 50 NEWMAN, RUSSELL W., and PAUL T. BAKER. Spatial Requirements of the Neck-Shoulder Region. Environmental Protection Division Technical Report EP-15, U. S. Army Quartermaster Research and Development Center, Natick, Mass., July, 1955. 13 pages (AD 66 269)

Dimensional analyses were performed on the neck-shoulder region of a sample of U. S. Army soldiers selected on the basis of body build. Measurements of neck height, neck-shoulder angle, acromial width, shoulder width, and a calculation of the square inches involved in two triangles, the shoulder and acromial triangles, are computed from photographs. Statistical tables of the four measured dimensions and two calculated areas are here presented in the form of reference data. Cutout models of the averages and statistical extremes are provided for graphic visualization. Loss of available space through the addition of a hypothetical quarter-inch layer of clothing is found to approximate one-third of the area in men with extremely small dimensions. Correlations between dimensions of the neck-shoulder region and total body measurements are too low for incorporation into a sizing system of clothing and equipment.

- 51 DANIELS, FARRINGTON, Jr., and PAUL T. BAKER. Shivering in Fat and Thin Men Exposed to Air Temperatures of 15°C. Paper presented at a meeting of the American Physiological Society, Medford, Mass., September, 1955.

Abstract not available.

- 52 NEWMAN, RUSSELL W. Reconstruction of Body Build from the Human Skeleton. Paper presented at the 8th Summer Seminar in Physical Anthropology, Washington, D. C., September, 1955.

Abstract not available.

- 53 NEWMAN, RUSSELL W. Adaptation in Modern Man. Paper presented at a meeting of the American Anthropological Association, Boston, Mass., November, 1955.

Abstract not available.



- 54 BAKER, PAUL T., and FARRINGTON DANIELS, Jr. Relationship Between Skinfold Thickness and Body Cooling for Two Hours at 15°C. *Journal of Applied Physiology*, Vol. 8, No. 4, 409–416, January, 1956.

Body fat, with its low thermal conductivity, has long been considered an important insulator in protecting the body from cooling in cold environments. The present investigation is a study of some of the quantitative aspects of the reactions of the human body to standard cooling conditions, as these reactions relate to body fat content.

By means of correlation coefficients and regression equations between skinfolds and skin and rectal temperatures, it has been demonstrated that when almost nude men are inactive at 59°F (15°C), fat acts as an insulator. Fat men, under the environmental and activity conditions described, maintain higher rectal temperatures but have lower skin temperatures than thin men. The differences between 1 and 19% body fat produces a difference of 1.2°F (0.7°C) in rectal temperature and 5.9°F (3.3°C) in mean weighted skin temperature during 2 hours of cold exposure.

- 55 WHITE, ROBERT M. Body Build and Body Weight in 25-year-old Army Men. *Human Biology*, Vol. 28, No. 2, 141—145, May, 1956. Also published as a chapter in: JOSEF BROZEK (editor) **Body Measurements and Human Nutrition**, Wayne University Press, Detroit, Mich., 1956. (Library of Congress Catalog Card No. 56—11646)

An analysis of weight and body build was carried out on a series of approximately 3550 25-year-old White Army separatees. For each inch of stature, mean weights are presented for small, medium, and large groupings of chest breadth and bi-iliac diameter. These results are compared with a table of desirable weights for men of age 25 or over, published by the Metropolitan Life Insurance Company of New York.

The material presented in this paper represents only a preliminary investigation of the problem of laterality in body build. However, the weights presented are those for definite categories of body size as determined by the use of chest breadth and bi-iliac diameters. The weights shown in the Metropolitan Life Insurance table, although they approximate fairly closely the Army values, are for categories of body size in which the determination of the size of the frame is not specified or defined in terms of any body diameter.

- 56 NEWMAN, RUSSELL W. Skinfold Measurements in Young American Males. Human Biology, Vol. 28, No. 2, 1954—164, May, 1956. Also Published as a chapter in: JOSEF BROZEK (editor) **Body Measurements and Human Nutrition**, Wayne University Press, Detroit, Mich., 1956. (Library of Congress Catalog Card No. 56—11646)

The growing use of skinfold measurements obtained with constant-pressure calipers has emphasized the need for large-scale surveys of selected populations to develop standards against which future studies can be compared. No single survey will be adequate in this field even within one population, because age, sex, and physical activity differences will require subsampling beyond the capacity of most surveys. This report is not definitive, even in its selected sample of young American adult males, but it should provide data more extensive than presently available. This report will cover two aspects of the skinfold measurements obtained on these men. One: the basic statistics on the measurements will be presented for the use of other workers in the field. Two: geographical and racial groups will be contrasted to show interesting differences between regional subsamples.

Skinfold measurements and derived measures of body composition were obtained on a large series of young White adult males and a smaller series of young American Negro Males. The limited age range and possible effects of military selection may restrict the applicability of the data for other purposes but not the internal reliability for comparisons. A racial contrast emphasized the leanness of the young Negro male and his distinctive deficiency of subcutaneous fat over the pectoral and triceps regions. Geographic grouping of the men indicated a regional difference between northerners and southerners in the amount of body fat for both Whites and Negroes. The causes of these differences in body fat are not fully clear but their relevance to human nutritional and ecological research is obvious.



- 57 WHITE, ROBERT M. Weight and Body Build of 25-year-old Army Men. (Paper presented at the 25th annual meeting, American Association of Physical Anthropologists, Chicago, Ill., April, 1956). American Journal of Physical Anthropology, N.S. Vol. 14, No. 2, 374, June, 1956.

Abstract: In an investigation of weight and body build among Army men, an analysis of the relationship between weight and size of frame has been carried out, utilizing data on a series of approximately 3550 25-year-old White Army separatees. Three categories of frame size were established, based upon groupings of men having small, medium, and large chest breadth and bi-iliac diameters. For each inch of stature, mean body weights were derived for men of small, medium, or large frames.

- 58 McKERN, THOMAS W. The Symphyseal Formula: A New Method for Determining Age from Pubic Symphyses. (Paper presented at the 25th annual meeting, American Association of Physical Anthropologists, Chicago, Ill., April, 1956). American Journal of Physical Anthropology, N.S. Vol. 14, No. 2, 388, June, 1956.

Abstract: In determining skeletal age from the pubic symphysis, it is customary to use Todd's ten typical age phases. Although these phases are supposed to represent the appearance of the symphysis over periods of time from two to five years in extent and thus ignore the variability within these age periods, surprisingly little effort has been made to improve this system.

Confronted with the problem of analyzing a set of 375 casts of pubic symphyses obtained by Dr. T. Dale Stewart in 1954–1955 from skeletons of American soldiers killed in Korea, and having in mind that the purpose of the analysis was age identification, a new system of formulation had to be devised. The solution of this problem has involved a symphyseal formula similar in many aspects to the formula used in somatotyping. In the symphyseal formula, it seems desirable to use three components divided into five chronological stages. By determining the age distribution of each component stage it is possible to translate any given formula into the most likely age at time of death with its probable error. This paper will be limited to a discussion of the symphyseal formula, emphasizing its advantages over the more static phase system of Todd's.

- 59 KOBRIK, JOHN L. Quartermaster Human Engineering Handbook Series: I. Spatial Dimensions of the 95th Percentile Arctic Soldier. Environmental Protection Research Division Technical Report EP-39, U. S. Army Quartermaster Research and Development Center, Natick, Mass., September, 1956. 86 pages (AD 114 058)

Section III, Paragraph 8(2) of AR 705-5 states as follows: "The satisfactory development of an item of materiel cannot be achieved without full and timely consideration of the principles of human engineering." For the most part in the past, human engineering considerations have been based upon the characteristics and capabilities of the unrestricted man operating equipment in an ideal environment. However, these characteristics, capabilities and requirements may be altered completely when the soldier is fully equipped and operating under various combinations of natural and military environmental situations. To insure maximal operational effectiveness, the man, his clothing and equipment and the machines to be operated must be fully integrated, and human engineering compatibility between the QM-equipped soldier and other military materiel must be achieved. It is the responsibility of the Quartermaster Corps to gather and integrate and provide the data on the abilities, limitations and spatial dimensions of the QM-equipped soldier to the Department of the Army design engineers for use in the development of new items of military materiel.

This report presents human engineering information on the body size of the soldier clothed in the full Arctic uniform. It should be used as a handbook by engineers and designers for establishing space allowances in the design and sizing of man-operated equipment. The criterion used is the 95th percentile of Army nude body size, so that the data are concerned with the upper size limit. The information is presented in pictorial form with index scales, so that dimensions can be measured on the pictures and referred to the index scale to establish actual size.



- 60 KOBRIK, JOHN L. Quartermaster Human Engineering Handbook Series: II. Dimensions of the Upper Limit of Gloved Hand Size. Environmental Protection Research Division Technical Report EP-41, U. S. Army Quartermaster Research and Development Center, Natick, Mass., December, 1956. 185 pages (AD 127 124)

Protection of the hand from cold or traumatic injury presents a complex problem. Every conceivable method for protecting the hand to some degree interferes with the ability to do things with the hand. Hand dexterity, sensitivity and functional capabilities are all limited by handwear. To the designer of hand-operated equipment, handwear presents the further problem of designing the equipment to accommodate the gloved hand. Knobs, levers, switches, triggers, etc. must be properly sized and spaced to permit satisfactory operation by the man wearing cold weather handwear.

This report presents human engineering information on the hand size of the soldier wearing various ensembles of Quartermaster protective handwear. It is intended for use as a handbook by engineers for establishing size and space allowances in the design and sizing of hand-operated equipment. The criterion employed is the bare hand size that is equal to or bigger than the hand size of 95% of the Army personnel; i.e., the 95th percentile of the Army hand size distribution. The information is presented in pictorial form with index scales, so that dimensions can be measured on the pictures and referred to the index scale to establish actual size.

- 61 KOBRICK, JOHN L. Quartermaster Human Engineering Handbook Series: III. Dimensions of the Lower Limit of Gloved Hand Size. Environmental Protection Research Division Technical Report EP-43, U. S. Army Quartermaster Research and Development Center, Natick, Mass., February, 1957. 185 pages (AD 137 961)

To insure effective operation of equipment, sufficient space must be allowed to accommodate the operator wearing the clothing and protective equipment required for the environment. The design engineer could readily achieve this objective by providing for generous space allocation. However, this would in most instances increase the size of the equipment to unacceptable levels. It is only by knowing the maximal and minimal body dimensions of the equipped Army personnel that adequate space allocations can be provided on a rational basis. This series of human engineering handbooks, of which this is the third, is designed to provide such guidance information.

This report presents human engineering information on the hand dimensions of the soldier wearing various ensembles of Quartermaster protective handwear. It should prove useful to engineers and designers as a handbook for establishing size and space allowances in the design and sizing of hand-operated equipment. The criterion used is the point below which the smallest five percent of hand sizes fall; therefore, the data are concerned with the lower limit of hand size. The information is presented in pictorial form with index scales, so that dimensions can be measured on the pictures and referred to the index scale to establish actual size.

- 62 KOBICK, JOHN L. Quartermaster Human Engineering Handbook Series: IV. Dimensions of the Lower Limit of the Body Size of the Arctic Soldier. Environmental Protection Research Division Technical Report EP-51, U. S. Army Quartermaster Research and Development Center, Natick, Mass., April, 1957. 83 pages (AD 142 864)

The importance of the full and timely consideration of the principles of human engineering for the satisfactory development of items of materiel has become recognized in Army doctrine (AR 705-5). To insure effective operation of equipment, sufficient space must be allowed to accommodate the operator wearing the clothing and protective equipment required for the environment. It is only through knowledge of the maximal and minimal body dimensions of equipped Army personnel that adequate space allocations can be provided on a rational basis. Because the military operator is provided with Quartermaster clothing and equipment, it is the responsibility of the Quartermaster Corps to provide the dimensions of clothed body size to the Army design engineer for use in the development of compatible man-machine systems.

This report presents human engineering information on the body size of the soldier clothed in the full Arctic uniform. It should be used as a handbook by engineers and designers for establishing space allowances in the design and sizing of man-operated equipment. The criterion used is the point below which the smallest five percent of body sizes fall; therefore, the data are concerned with the lower limit of body size. The information is presented in pictorial form with index scales, so that dimensions can be measured on the pictures and referred to the index scale to establish actual size.



- 63 McKERN, THOMAS W., and T. DALE STEWART. Skeletal Age Changes in Young American Males, Analyzed from the Standpoint of Age Identification. Environmental Protection Research Division Technical Report EP-45, U. S. Army Quartermaster Research and development Center, Natick, Mass., May, 1957. 179 pages (AD 147 240)

This report of skeletal age changes was compiled from the results of extensive identification research on a series of 450 skeletal remains of U. S. war dead repatriated from North Korea under "Operation Glory" during the fall of 1954. The report is divided into eleven chapters; ten outline the progress of age changes in selected skeletal segments, and one, the eleventh, portrays the total pattern of skeletal maturation. To further aid the observer, each chapter includes complete tabular and detailed photographic evidence of the exact nature of skeletal age changes for the particular area concerned. Also, new methods for determining age estimations have been introduced.

The present work can be used as a technical source as well as a practical tool for the age identification of unknown remains.

- 64 BAKER, PAUL T., and RUSSELL W. NEWMAN. The Use of Dry Bone Weights for Identification. Environmental Protection Research Division Technical Report EP-55, U. S. Army Quartermaster Research and Development Center, Natick, Mass., May, 1957. 22 pages (AD 138 270)

The skeletal remains of one hundred and twenty-five individuals were dried and weighed to investigate the feasibility of using bone weight for estimating living weight and for segregating individuals in group burials. Skeletal components formed differing proportions of total skeletal weight in Whites and Negroes; therefore, the racial groups were analyzed separately. Broad categories of living weight can be predicted from total dry skeletal weight or from the weight of dry right femur. The accuracy of prediction is even greater when the procedure is reversed, that is, predicting dry right femur weight from living weight and stature. The separate dry bone weights of the skeleton were found to be closely correlated to each other in most cases; in conjunction with length measurements they may be used for a highly reliable method of segregating commingled remains into individuals. The regression equations and a practical example for segregating individuals are provided in the appendices.

- 65 BAKER, PAUL T. Spatial Dynamics of the Neck-Shoulder Region. Environmental Protection Research Division Technical Report EP-56, U. S. Army Quartermaster Research and Development Center, Natick, Mass., May, 1957. 17 pages (AD 137 929)

A study was made of the dimensional changes caused in the shoulder-neck area by movement. Twenty-one men were photographed, each in seven poses, and measurements were made on the enlarged photographs. The seven poses were chosen to show the effects on the measurements of moving the arm, head, and shoulder. The measurements included total shoulder length, effective shoulder length, total shoulder area, and effective shoulder area. Tables summarizing these measurements in each pose are given in the text, and their utility in clothing and equipment design is pointed out. It was concluded that the addition of any equipment or clothing in this region restricts movement, and that the design of any new item to be used or worn in this area should take into consideration the items already prescribed for the area, the movements of the region required to fulfill the prescribed military tasks, and the measurement of this area when the soldier is performing these tasks.



- 66 McKERN, THOMAS W. Estimation of Skeletal Age from Combined Maturational Activity. *American Journal of Physical Anthropology*, N.S. Vol. 15, No. 3, 399-408, September, 1957.

The calculation of age at death from the observed status of skeletonized remains is one of the principal identification methods provided by the physical anthropologist. While the application of this technique has long proved invaluable to both military and civilian agencies involved in identification work, there exist inherent limitations which arise partially from the subjective nature of the method as well as the lack of well documented skeletal series with adequate age coverage. Within the framework of subjective method, it is generally believed that because of the high variability of individual maturative events more precise age estimations may be derived by pooling all available criteria and giving final age assessments as crude averages. Thus, as research on the maturative activity of new areas is completed, they are added to the list of ageing criteria on the assumption that each new addition tends to further minimize excessive individual weighting. However, the validity for combining many individual observations has never been objectively tested for methods of age identification. Based on an analysis of data collected on a thoroughly documented sample of American war dead, it is the purpose of this paper to test the application of the concept of combined maturation as it relates to estimations of skeletal age.

The degree of relationship between combined maturational score and age has been tested for five groups of skeletal growth areas. The data indicate that an age estimation derived from the combined maturational activity of a small group of critical growth areas is as reliable as an estimation based on the total number of maturative events. To the identification specialist, this information means that instead of the usual practice of emphasizing complete skeletal coverage, dependable age estimations can be obtained from the combined maturational activity of a small number of critical areas. Also, because of the tested reliability of the symphyseal surface of the pubic bone, the use of other ageing criteria is necessary only where the pubic symphysis is damaged or missing (at least for age groups over 17 years).

- 67 WHITE, ROBERT M. Applied Anthropometry of the Foot. (Paper presented at the 26th annual meeting, American Association of Physical Anthropologists, Ann Arbor, Mich., April, April, 1957). American Journal of Physical Anthropology, N.S. Vol. 15, No. 3, 445, September, 1957.

Abstract: One aspect of military research and development in the Quartermaster Corps is concerned with the anthropometry of the foot and the development of military footwear. In recent years, this effort has followed the pattern of data collection, analysis and synthesis, application and testing. In this paper, available sources of anthropometric data on the foot are reviewed and several types of analyses are discussed. Several examples of the applications of anthropometric measurement and analysis are presented.

- 68 NEWMAN, RUSSELL W. Xeroradiography — A New Technique for Living Anatomy. (Paper presented at the 26th annual meeting, American Association of Physical Anthropologists, Ann Arbor, Mich., April, 1957). American Journal of Physical Anthropology, N.S. Vol. 15, No. 3, 448, September, 1957.

Abstract: Operational procedures of a new radiographic medium, Xeroradiography, are illustrated and explained. This technique which uses photosensitized selenium-coated plates instead of conventional X-ray film and utilizes a dry developing method emphasizes small, sharp discontinuities in bone with remarkable presentation of soft parts detail. Its speed of development, absence of sensitivity to background radiation, and wide density latitude make it appear ideal for use in a military war dead identification program as a method of locating and analyzing healed bone fractures.



- 69 BAKER, PAUL T., and RUSSELL W. NEWMAN. The Use of Bone Weight for Human Identification. American Journal of Physical Anthropology, N.S. Vol. 15, No. 4, 601-618, December, 1957.

Within the past few years physical anthropologists have become increasingly involved in the problems of human identification. Techniques have been applied to individuals which were originally devised for the description of groups, and while these are the best available, they do not provide the desired certainty for the identification of an individual. Recent work on identification criteria has concentrated on improving the existing methods. There is obviously a need not only for the improvement of older methods, but also for the establishment of new criteria. With this in mind, research was undertaken by Army Graves Registration Service Headquarters, Kokura, Japan, on the war dead remains that were being repatriated during "Operation Glory."

The skeletal remains of 125 individuals were dried and weighed to investigate the utility of bone weight for identification and for segregating individuals in group burials. Skeletal components formed differing proportions of total skeletal weight in Whites and Negroes; therefore, the racial groups were analyzed separately.

It was found that broad categories of living weight can be predicted from total dry skeletal weight or from the dry right femur weight. However, the reliability of associating bone weights with living measurements can be increased by reversing the procedure, that is, predicting dry right femur weight from living weight and stature. The separate dry bone weights of the skeleton were found to be closely correlated to each other in most cases; in conjunction with length measurements they may be used for a highly reliable method of segregating commingled long bones into individuals. The regression equations and a practical example for segregating individuals are provided in the appendices.

- 70 BAKER, PAUL T., EDWARD E. HUNT, JR., and TULIKA SEN. The Growth and Interrelations of Skinfolts and Brachial Tissues in Man. *American Journal of Physical Anthropology*, N.S. Vol. 16, No. 1, 39–58, March, 1958.

A set of latero-medial radiographs of the brachium were taken in a series of children and adults of both sexes. On the children, skinfolts were also measured. The radiographic tissue shadows were transformed into areas of cross section of the brachium so that the growth of the marrow cavity, compact bone of the humerus, musculature and subcutaneous adipose layer could be measured separately. These areas were chosen to assess "parsimoniously" the growth of these tissues.

Like previous investigators, we found that skinfolts efficiently predict the radiographic thickness of skin plus subcutaneous tissue. Specific equations, however, are probably needed for specific sites, age ranges, and perhaps even in some cases for males and females.

As earlier workers have noted, females tend to have thicker skinfolts than males at all ages past early infancy. The relative concentration of this tissue in the trunk in girls is exaggerated after pubescence.

In the brachium, boys show a decline in the percentage of adipose tissue from childhood to maturity. Girls show a far smaller decline until pubescence, and then a small increase. At all ages, the average female brachium is more adipose than that of the male, and in the young adult the sex difference is more than two to one. The age-stability of composition of the female brachium apparently corresponds to an equal stability of body composition in the female which seems to begin no later than 10 years of age.

In both sexes, the lean brachium has a similar size and composition until about 10 years of age. In older boys, the size of the brachial muscles nearly doubles while girls show only a slight increase in muscle mass.

At 6 years of age, the female brachium contains more compact bone than that of the male. At 8 years of age and older, humeral area is greater in males. In adolescence, the periosteum is far more active in boys than in girls, and this may produce the rugged surface details and massiveness of the mature male skeleton.

In boys, endosteal resorption keeps pace with periosteal apposition through adolescence. In girls, however, the marrow cavity reaches its adult size by 12 years of age. Some connection may exist between this cessation of growth and the great increase of estrogen secretion at this age.

In the adult male series, the correlations among the cross-sectional areas of marrow, compact bone, muscle and subcutaneous adipose tissue are all low, and most were not significantly greater than zero. This independence of size of brachial tissues justifies the separate measurement of each constituent in researches on mechanisms of growth. This finding also discredits the anatomical basis of the mesomorphic scale of constitutional assessment, which is supposedly based on the covariation of bone width, cortical thickness, and muscle size. The lack of significant correlation between bone and muscle size emphasizes that one should not exaggerate the interdependence of these tissues in their amounts and patterns of growth.



- 71 TROTTER, MILDRED, and GOLDINE C. GLEESER. A Re-evaluation of Estimation of Stature Based on Measurements of Stature Taken During Life and of Long Bones after Death. (Contract DA19-129-qm-562, Department of Anatomy, Washington University, St. Louis, Mo.). American Journal of Physical Anthropology, N.S. Vol. 16, No. 1, 79-123, March, 1958.

This study of estimation of stature from length of long limb bones is the second to be based on measurements of stature during life and of bones after skeletonization. The first study was based on American military males who were casualties of World War II, the present study on casualties of the Korean War. The present data include much larger series of both Whites and Negroes than did the first study and, also, small series of Mongoloids, Mexicans, and Puerto Ricans.

Regression equations for estimation of stature of American males of each of the five groups have been determined from these data. The relationships of stature to length of long limb bones differ sufficiently among the three major races (White, Negro, Mongoloid) to require different regression equations from which to derive the most precise estimates of stature for individuals belonging to each of these groups. The Puerto Rican group, although of shorter stature than the American Negro, presents in this series of data approximately the same relationship of stature to length of long bones as does the Negro group, and thus the equations for estimation of stature derived from the data of the Negro series are applicable to Puerto Ricans. The proportions found in the small sample of Mexicans differ sufficiently from those of any of the other four groups to indicate that more precise estimates of stature for Mexicans will be determined from equations derived from the data of the Mexican series than from any of the other four series.

The standard errors of estimates of stature from lengths of long bones are larger in the present series of White males than in the series of the previous study. The primary reason for this difference is attributed to the evidence that stature and its relationship to long bone lengths are in a state of flux, since some individuals over 21 years of age with given bone lengths are taller today than were individuals six to ten years ago with the same bone lengths.

American White males of the present generation are continuing to grow up to at least 21, and possibly 23, years of age before maximum stature is attained. This finding is in contrast to that obtained from extensive World War II data in which there was no significant increase in stature after 18 years of age. The longer period of growth in stature of the present military series than of the World War II series and the nature of the growth curve for this terminal period were substantiated in two sets of longitudinal growth data, wholly unrelated to the military series. It is probable that growth in stature is occurring after 18 years of age in all groups in the U.S.A. at the present time. By using the theoretical growth curve with constants computed from the American White military data, averages of the amount

of increase in stature for each one-half year interval are provided from age 17 to 21 years. These averages should be applied, when appropriate, to observed or "presumed stature." The application is indicated in identification problems which involve a time lapse between the measuring of stature and the completion of growth in stature.

On the basis of the difference found in stature-long bone length relationships between the World War II and Korean War series, it is indicated that equations for estimation of stature should be derived anew at opportune intervals.

- 72 BAKER, PAUL T. American Negro-White Differences in Heat Tolerance. Environmental Protection Research Division Technical Report EP-75, U. S. Army Quartermaster Research and Engineering Center, Natick, Mass., June, 1958. 23 pages (AD 201 112)

The physiological responses of American White and Negro soldiers were studied under hot-wet and hot-dry conditions. Under hot-wet conditions 40 pairs of men matched for body fat, weight, and stature were walked around a course at 3½ mph for one hour. Under hot-dry conditions, 8 pairs of men also matched for body fat, weight, and stature were studied under 8 different conditions which included combinations of clothing, sun, shade, walking, and sitting.

The results of this series of experiments indicated:

- 1) Under hot-wet conditions with both Negroes and Whites clothed and walking, the Negroes had a higher physiological tolerance.
- 2) Under hot-dry conditions with both groups clothed, walking, or sitting, they had about equal tolerance.
- 3) Under hot-dry conditions with both groups nude and exposed to the sun, sun-tanned Whites had the higher tolerance.

These results further suggested that the differences found were not a function of transient environmental effects and are mostly genetic in origin.



- 73 BAKER, PAUL T. A Theoretical Model for Desert Heat Tolerance. Environmental Protection Research Division Technical Report EP-96, U. S. Army Quartermaster Research and Engineering Center, Natick, Mass., July, 1958. 32 pages (AD 201 113)

Man probably evolved in a subtropical climate; consequently, he is best adapted to these conditions. However, with a minimum of cultural aids he later spread into most of the world's climatic zones. This spread implies that there was probably secondary adaptation to cold and hot climatic conditions.

Experimental and actuarial data indicate that there is a high degree of individual variance in ability to tolerate hot desert conditions. The same data also show that a significant percentage of this variance is correlated to morphological characteristics. From these relationships a "model" was constructed. The model of "ideal" man for tolerance of desert heat was found to be linear, low in subcutaneous body fat, acclimatized, and of brunette skin color.

These characteristics in the adult are all the product of genetic inheritance working through the environment and, with the exception of acclimatization, training can do very little to modify them.

A survey of world populations indicated a trend for desert populations to conform more closely to the model than other populations. This trend may be considered further confirmation of the validity of the model and it was concluded that, first, desert populations show genetic adaptations to the climate and second, the model characteristics may be used to select groups of men who are above average in desert heat tolerance.

- 74 McKERN, THOMAS W. The Use of Short Wave Ultra-Violet Rays for the Segregation of Commingled Skeletal Remains. Environmental Protection Research Division Technical Report EP-98, U. S. Army Quartermaster Research and Engineering Center, Natick, Mass., August, 1958. 11 pages (AD 202 754)

The identification specialist is often confronted with human skeletal remains that comprise two or more individuals. By using a combination of standard techniques, such as articulation, bi-lateral and serial symmetry, osteometry, and reconstruction, he may achieve accurate segregation after long and careful analysis. As a part of the Quartermaster Corps research program to improve present identification techniques, as well as to devise new methodology for the identification of American war dead, the present study described and evaluates a fast and simple test for sorting individual remains from mixed burials.

When bone surfaces are exposed to short wave ultra-violet irradiation, most of them reflect a variety of colors. The wide range of color emission, as well as the fixed relationship to these colors to the substances that emit them, is justification for attempting to apply these qualities to the segregation of commingled skeletal remains.

After demonstrations of the results of ultra-violet exposure on a large sample of skeletal material, it is suggested that short wave ultra-violet lamps can be used in certain instances for the accurate sorting of commingled remains.

- 75 BAKER, PAUL T. Racial Differences in Heat Tolerance. American Journal of Physical Anthropology, N.S. Vol 16, No. 3, 287-305, September, 1958.

The science of genetics has emphasized the importance of natural selection in the formation of taxonomic races. This in turn indicates the desirability of a re-evaluation of human races in terms of the possible sources of selective forces. Such a re-evaluation may be based on ecological inferences from the distribution of modern races; or specific hypothesis may be tested by experimental means.

It is the purpose of this study, using the experimental approach, to compare the heat stress resistance (heat tolerance) of Negroes and Whites. The development of this type of knowledge will eventually permit us to define some of the role of climate in the selection of certain morphological characteristics.

The physiological responses of American White and Negro soldiers were studied under hot-wet and hot-dry conditions. Under hot-wet conditions 40 pairs of men matched for body fat, weight, and stature were walked around a course at 3½ miles per hour for one hour. Under hot-dry conditions 8 pairs of men also matched for body fat, weight and stature were studied under eight different conditions which included combinations of clothing, sun, shade, walking, and sitting.

The results of this series of experiments indicated that:

1. Under hot-wet conditions with both Negroes and Whites clothed and walking, the Negroes had a higher physiological tolerance.
2. Under hot-dry conditions with both groups clothed, walking, or sitting they had about equal tolerance.
3. Under hot-dry conditions with both groups nude and exposed to the sun, sun-tanned Whites had the higher tolerance.

These results further suggested that the differences found were not a function of transient environmental effects and may be mostly genetic in origin. The results are discussed in relation to racial taxonomy systems and the distribution of human morphological attributes.



- 76 JONES, CHARLES E., JOHN L. KOBRICK, and HENRY F. GAYDOS. Anthropometric and Biomechanical Characteristics of the Hand. Environmental Protection Research Division Technical Report EP-100, U. S. Army Quartermaster Research and Engineering Center, Natick, Mass., September, 1958. 20 pages (AD 204 867)

Optimal design of manually-operated equipment and of handwear which provides environmental protection must take into consideration the size, shape, and relationships between the various parts of the human hand, and the types and amount of movements and forces that the hand and parts of the hand can accomplish. Such data on the structural and functional characteristics of the hand are widely scattered through the scientific literature, frequently in a form quite unusable by the design engineer. The need to collate, synthesize, and present such pertinent data in a form readily available for use by design engineers was recognized by the scientists familiar with the sources of the information and the present report was prepared to fill this need.

Descriptive data are presented on the structural and functional characteristics of the human hand which are of interest to engineers concerned with the design of handwear and manually-operated equipment. The first section deals with the anthropometric dimensions of the hand, and shows the centile distribution of component hand sizes in several military population samples. The second section reviews data on the biomechanics of the hand in terms of direction, range, and forces involved in typical functional movements.

- 77 NEWMAN, RUSSELL W. Small Unit Clothing Tariffs. Paper presented at the 4th Annual Army Human Factors Engineering Conference, Baltimore, Md., September, 1958.

Abstract not available.

- 78 HOOTON, EARNEST A. Body Build in a Sample of the United States Army. Contract Reports (Contracts W44-109-qm-1078 and 2014), Department of Anthropology, Harvard University, Cambridge, Mass. Environmental Protection Research Division Technical Report EP-102, U. S. Army Quartermaster Research and Engineering Center, Natick, Mass., February, 1959. 358 pages (AD 214 177) (Publication of Contract Reports submitted in 1948 and 1949)

The two reports which comprise this volume represent a unique experiment in the analysis of body build and the final scientific accomplishment of the author, Earnest A. Hooton, Professor of Anthropology at Harvard University. His untimely death in 1954 left this work in the form of two contractor's reports, each reproduced in only a handful of copies and those scattered into some very obscure governmental and academic corners. On the other hand, there have been an amazing number of references to these reports and citations from them in anthropological literature by authors who could not have had even continuous access to a copy. This Command continues to receive requests for these reports — requests that could not be filled from the single file copy of each on hand. In the year or two preceding his death, Professor Hooton indicated his awareness that the limited number of copies restricted the full utilization of this work and spoke of reorganizing the material for publication as a book — a process of popularizing scientific work at which he was extremely successful.

We have not attempted to rewrite Dr. Hooton's reports — the only factual changes have been to correct typographical errors (principally statistical) which could be identified by cross-checking between the tables and the text. In any event, the real worth of these reports is in the statistical tabulations of data on a sample which may never be equalled for size and coverage. It is with the feeling that such a fund of scientific information cannot be allowed to lapse into obscurity that this reprinting of Dr. Hooton's reports was undertaken.

Part I covers: (1) the general distribution of body types classified into 18 groups, as determined from the assessments of individuals by morphological studies of photographs and the use of the stature divided by the cube root of weight index; (2) the military utility of each of the several groups, whether for combat or service, as indicated by the extent to which various body types tended to be concentrated in distinct Army units and specialties; (3) the correlations of the body build groups with all sociological and other data compiled in the survey, such as age, months of service, birthplace, etc.

Part II deals with the more important measurements gathered on individual soldiers during the course of the survey, as such measurements apply to various body types, previously determined from the photographs.



- 79 KOBICK, JOHN L. Quartermaster Human Engineering Handbook Series: VI. Size Limits of the Head and Neck Area of the Soldier Wearing Quartermaster Headgear. Environmental Protection Research Division Technical Report EP-107, U. S. Army Quartermaster Research and Engineering Center, Natick, Mass., March, 1959. 87 pages (AD 217 269)

The importance of the full and timely consideration of the principles of human engineering for the satisfactory development of items of materiel has become recognized in Army doctrine (AR 705-5). To insure effective operation of equipment, sufficient space must be allowed to accommodate the operator wearing the clothing and protective equipment required for the environment. It is only through knowledge of the maximal and minimal body dimensions of equipped Army personnel that adequate space allocations can be provided on a rational basis. Because the military operator is provided with Quartermaster clothing and equipment, it is the responsibility of the Quartermaster Corps to provide the dimensions of clothed body size to the Army design engineer for use in the development of compatible man-machine systems.

This report presents human engineering information on the size range of the head and neck area of the soldier wearing Quartermaster headgear. It should be used as a handbook by engineers and designers for establishing space allowances in the design and sizing of man-operated equipment. The criteria used are the points beyond which the largest 5 percent and the smallest 5 percent of head sizes fall; therefore, the data are concerned with the middle 90 percent of the range of head sizes for the Army population. The information is presented in pictorial form with index scales, so that dimensions can be measured on the pictures and referred to the index scales to establish actual size.

- 80 McKERN, THOMAS W., and ELLA H. MUNRO. A Statistical Technique for Classifying Skeletal Remains. *American Antiquity*, Vol. 24, No. 4, 375—382, April, 1959.

Summary not available.

- 81 SASSOUNI, VIKEN. Identification of War Dead by Means of Roentgenographic Cephalometry. Contract Report (Contract DA19-129-qm-739), Graduate School of Medicine, University of Pennsylvania, Philadelphia, Pa. Environmental Protection Research Division Technical Report EP-125, U. S. Army Quartermaster Research and Engineering Center, Natick, Mass., February, 1960. 71 pages (AD 237 496)

It is axiomatic in the field of war-dead identification that successful identification is largely a function of how much we know about a given individual. Unfortunately, we don't know too much about our soldiers before death that materially assists in identification after death. The research here reported rests on just one assumption: that we had an additional piece of biological data — a postero-anterior X-ray of the head and face before death, and sought to establish what assistance this would be in identifying remains. The answer clearly was that it would be of great assistance, since a simple combination of head and face measurements taken from such X-rays is highly diagnostic. This research demonstrated a truth that is often forgotten: every soldier is a unique individual, and the implications and importance of individuality are worthy of continued emphasis.

This report describes a new method of identification of war dead by means of roentgenographic cephalometry. Head X-ray films were taken twice on 500 adult males. The most characteristic measurements were selected from the films. By a system of coding, tests of identification were performed with a high-speed computing machine. Measurements, selection, and identification took two minutes per person; 100% accuracy was obtained during these tests.

Suggestions have been made to improve the method and possibly to extend its use for the civilian population.

Publication of this research study should not be interpreted as an indication that the Army plans to utilize this means of identification in the foreseeable future.



- 82 KOBICK, JOHN L., and BRIAN CRIST. Quartermaster Human Engineering Handbook Series: VII. The Size and Shape of the Available Visual Field During the Wearing of Army Headgear. Environmental Protection Research Division Technical Report EP-133, U. S. Army Quartermaster Research and Engineering Center, Natick, Mass., May, 1960. 25 pages (AD 238 090)

The reduction of incompatibilities in military equipment systems requires that one know what limitations are placed on the operator by use of the equipment. In the case of headgear, the wearer's field of vision is almost sure to be reduced to some degree by the very fact that something with an overhang is placed on his head. By the time that essential physical protection has been built into the item, the field of vision may be restricted considerably. Knowledge of the extent of such limitations is essential to engineers and equipment designers engaged in the development of headgear and related equipment.

This report furnishes information in tabular form on the size and shape of available visual fields during the wearing of 12 Army headgear ensembles. Schematic diagrams are also provided to aid in visualizing size and shape of the visual fields.

- 83 McKERN, THOMAS W. The Fluorescence of Human Bone as Viewed Under Short Wave Ultra-Violet Rays. (Paper presented at the 27th annual meeting, American Association of Physical Anthropologists, Cambridge, Mass., April, 1958). American Journal of Physical Anthropology, N.S. Vol. 18, No. 4, 337, December, 1960.

Abstract: When most bone surfaces are exposed to short wave ultra-violet radiation, they react by reflecting a variety of colors. The wide range of color emission as well as the stable characteristic of these colors for the substances that emit them, is basis enough for attempting to apply these qualities to the segregation of commingled skeletal remains. After demonstrating the results of U—V exposure on a large sample of skeletal material, it is suggested that short wave ultra-violet lamps can be used in some instances for the accurate sorting of commingled remains.

- 84 SASSOUNI, VIKEN. A Method of Identification of War Dead by Means of Roentgenographic Cephalometry. (Paper presented at the 27th annual meeting, American Association of Physical Anthropologists, Cambridge, N.S. Vol. 18, No. 4, 338, December, 1960.

Abstract: The problem posed by the Quartermaster Research and Development Command was: "What are the five measurements of the head and face (as seen in the frontal and lateral x-ray films) which are the most variable, the least correlated, and the most reliable, that can be used for identification purposes? The mandible should not be included in more than one measurement. The test should be carried out on 500 adult males above eighteen years of age." This study was conducted at the Philadelphia Center for Research in Child Growth.

Four hundred and ninety-eight males were x-rayed twice with the Broadbent-Bolton roentgenographic cephalometer; the first set represents the ante-mortem films (AM) and the second set the postmortem films (PM). Two hundred and forty-eight were x-rayed in Philadelphia; seventy at the Bolton Fund, Western Reserve University; one hundred and twenty at the University of Illinois; and one hundred and ten at the National Institutes of Health. They represent grossly a cross-section of young adult American males.

For various reasons but basically in order to obtain the greatest variability for the minimum error, and, at the same time, to avoid tracing, linear dimensions were selected as the method of measurement. Twenty-four measurements were selected on the frontal film. Large error, low variations, and duplications eliminated sixteen of them. The remaining eight measurements are: frontal sinus breadth, facial height, bigonial, cranial height (mastoid-apex), incision height, bizygomatic, bimaxillary, and maximum cranial breadth. Twenty-four measurements were selected on the lateral film. The remaining eight measurements are: height of the cranium 8 cm posterior, 4 cm posterior, just above, and 4 cm anterior to center of the sella turcica; facial height (Na-Me); cranial length along Nasion-Sella, 4 cm above, and 8 cm above.

A table of correlation was computed among the sixteen selected measurements (eight frontals, eight laterals). From these sixteen, the five best measurements in terms of high variability, low error, and low correlation were selected by individual simultaneous computations. These five measurements are: length of cranium 4 cm above Na-S, sinus breadth, total facial height bigonial and bizygomatic breadths. They are the most characteristic of the individuality of an adult male.



Since four of the five selected measurements are from the frontal film, and in order to realize a 50% economy, an attempt was made to use only the frontal film for purposes of identification. A test was made to identify one hundred PM frontal films from 498 AM films. A special routine was written to permit location and neutralization of accidental errors. The test was conducted on a Univac machine. It took ten seconds for the Univac machine to locate the correct film out of 498 possibilities. Direct identification was made on 97%; 3% could be identified by direct comparison with the remaining films. It can be stated, therefore, that the test of identification was 100% successful.

Suggestions were made which, if adopted, may lead to: increasing the standardization of the entire process; decreasing the errors; creating a mobile roentgenographic unit; initiating a longitudinal study of the growth of head and face in adults.

In conclusion, identification can be realized with 100% accuracy. At the same time, the roentgenographic films gathered will constitute for medical and dental health units an invaluable source of information on one of the most vital areas of the human body.

- 85 WHITE, ROBERT M. Stature Increase in the U. S. Military Population. (Paper presented at the 28th annual meeting, American Association of Physical Anthropologists, Madison, Wis., May, 1959). American Journal of Physical Anthropology, N.S. Vol. 18, No. 4, 356, December, 1960.

Abstract: Evidences of increases in the average stature of the U. S. military population are reviewed from data available in the literature. It may be concluded that average stature in the U. S. military population did not change appreciably between the Civil War and World War I. However, it is apparent that average stature in the military population increased some 3/4ths of an inch between World War I and World War II.

- 86 NEWMAN, RUSSELL W. A Preliminary Report on a Longitudinal Growth Study of College Men. (Paper presented at the 28th annual meeting, American Association of Physical Anthropologists, Madison, Wis., May, 1959). American Journal of Physical Anthropology, N.S. Vol. 18, No. 4, 356, December, 1960.

Abstract: A two-year, longitudinal growth study was carried out by three universities, one eastern, one midwestern, and one far western, under contract with the Quartermaster Corps. Stature and other physical measurements were collected on the subjects at roughly six-month intervals. Preliminary analysis of only the stature data in relation to the chronological age of the subjects showed a pattern which differs markedly from all known age-stature series in that average stature was inversely proportional to age. In spite of this, the growth records indicate that stature increase over the two-year span was also inversely proportional to age. If the data from these three universities are accepted, some revisions of our concepts of population changes in stature during this century and prediction of growth rates seem required.



- 87 WHITE, ROBERT M. The Anthropometry of Army Aviators: A Preliminary Report. (Paper presented at the 29th annual meeting, American Association of Physical Anthropologists, Washington, D. C., May, 1960). American Journal of Physical Anthropology, N.S. Vol. 19, No. 1, 100, March, 1961.

Abstract: An anthropometric survey of Army aviators was recently completed by the Quartermaster Corps. In this survey, measurements were obtained on a series of 500 pilots, which represents a 10 percent sample of the Army aviator population. Forty anthropometric measurements were taken on each man; these data have been analyzed for application in the design, sizing, and human engineering of clothing and equipment in the field of Army aviation.

- 88 WHITE, ROBERT M. Anthropometry of Army Aviators. Environmental Protection Research Division Technical Report EP-150, U. S. Army Quartermaster Research and Engineering Center, Natick, Mass., June, 1961. 112 pages (AD 263 357)

Information on the body size of Army aviators is available for the first time in the form of anthropometric measurements. A series of 500 flyers, including both warrant and commissioned officers, represents a sampling of about 10 percent of the Army aviator population. The sample of Army aviators was measured at Fort Bragg, North Carolina; Fort Benning, Georgia; Fort Rucker, Alabama; and Fort Devens, Massachusetts; in October, 1959. The anthropometric data, consisting of some 40 body measurements, have been analyzed, and are presented in the form of a table of percentile distributions and 82 bivariate charts. These data may now be applied in problems of design, sizing, and tariffing of flight clothing and specialized equipment for Army aviators, as well as in other areas of human engineering which require the use of body size information in aviator-equipment-aircraft systems.

- 89 KENNEDY, STEPHEN J., ROBERT L. WOODBURY, and HERMAN MADNICK. Design and Development of Natural Hand Gloves. Clothing and Equipment Development Branch Series Report No. 33, U. S. Army Quartermaster Research and Engineering Center, Natick, Mass., July, 1962. 33 pages (AD A047 962)

This report describes and discusses a process in which master model hands and hand forms were developed. Three pairs of master model hands, designated as sizes small, medium, and large, were sculptured. The hands were modeled in a relaxed position, with the palms and fingers in a natural, curved shape. Following this, metal dipping forms and experimental gloves were fabricated. A sizing study was then conducted on a series of 285 men, and it was determined that a high percentage of the male military population could be expected to be properly fitted with four sizes of gloves provided. Subsequently, porcelain dipping forms also were fabricated.

As a result of this work, it was concluded that the measurements of the experimental master model hand forms can be used as the basis of design and measurements of all types of dipped handwear developed by the Quartermaster Corps for use by Army personnel. Fabric lined vinyl coated gloves can be manufactured over dipping forms based on the experimental master model hands which meet the size and design requirements of the Army. Unsupported rubber, or rubber type gloves can be manufactured over porcelain dipping forms designed and developed by the Quartermaster Corps. These forms are available to the glove dipping industry for either military or commercial application.



- 90 NEWMAN, RUSSELL W., and ELLA H. MUNRO. Stature Growth Prediction in Young Men. (Paper presented at the 31st annual meeting, American Association of Physical Anthropologists, Philadelphia, Pa., May, 1962). American Journal of Physical Anthropology, N.S. Vol. 21, No. 3, 408, September, 1963.

Abstract: Skeletal identification by comparison of previous living height with stature calculated from long bone lengths is a common anthropological problem. The technique is complicated by a number of sources of inaccuracies: the inherent statistical error of the living stature prediction, the complicating factor of racial and sex differences, and for young individuals the question of allowances for growth since the last living height assessment. Three variables are usually considered important in making a growth correction in stature reconstruction: (1) the age of the individual, (2) whether he was short or tall, and (3) the amount of time that has transpired. A longitudinal stature study of young college men provides information on all of these variables and allows comparison with previous series which used a purely cross-sectional approach.

- 91 WHITE, ROBERT M., and ALBERT DAMON. Skinfold Measurements of Turkish, Greek, and Italian Military Personnel. (Paper presented at the 31st annual meeting, American Association of Physical Anthropologists, Philadelphia, Pa., May, 1962). American Journal of Physical Anthropology, N.S. Vol. 21, No. 3, 410, September, 1963.

Abstract: During the course of a NATO anthropometric survey in 1960-61, skinfold thickness measurements were obtained on some 3,350 military personnel in Turkey, Greece and Italy, including representative samples from the Army, Navy, and Air Forces in each country. This paper is a preliminary report on the skinfold measurements which have been utilized for an estimation of the amount of body fat.

The sample from Turkey showed the lowest means for stature, weight, and percent body fat; the Greek sample was intermediate; and the Italian sample showed the highest means for stature, weight, and percent body fat. Jet pilots were found to be the oldest and heaviest group in each country, as well as the group having the most body fat. Italian and Greek Air Force cadets were the tallest samples, as well as the youngest. While showing moderately high mean weights, these young men were relatively low in body fat, thus indicating a generally muscular build. The lowest mean weights and the lowest amounts of body fat were found in Turkish Air Force cadets and Turkish Army personnel.

Skinfold thicknesses measured at various sites on the body during the NATO survey are further discussed and compared with similar data on samples from the United States military population.

- 92 NEWMAN, RUSSELL W. A Simplified Technique for Assessing Cold Acclimatization. (Paper presented at the 32nd annual meeting, American Association of Physical Anthropologists, Boulder, Colo., May, 1963). American Journal of Physical Anthropology, N.S. Vol. 21, No. 3, 426, September, 1963.

Abstract: The eventual onset of gross body shivering as the result of a cold exposure is a well-known phenomenon. The time of onset and the frequency of the shivers are proportional to the level of cold exposure, the extent of the subject's cold acclimatization, and the individual patterns of the subject's cold response. This paper presents data from three studies designed to validate a technique whereby the number of shivers per standard cold exposure are recorded and integrated with short bursts of radiant heat for the purpose of allowing only sufficient rewarming to prevent the shivers from becoming continuous. Data from the same test, given at different ambient temperatures, from before and after studies of a group of artificially cold acclimatized subjects, and seasonal changes throughout a yearly cycle, will be presented.



- 93 WHITE, ROBERT M. Skinfold Thickness Measurements. Chapter 5 in: H. T. E. HERTZBERG, EDMUND CHURCHILL, C. WESLEY DUPERTUIS, ROBERT M. WHITE, and ALBERT DAMON. **Anthropometric Survey of Turkey, Greece, and Italy**. AGARDograph 73, The Macmillan Company, New York, N. Y., 1963. (AD 412 428) (Library of Congress Catalog Card No. 63-17517)

Skinfold thickness data were obtained on Turkish, Greek, and Italian military personnel during the NATO anthropometric survey of 1960-1961. Skinfold thickness measurements at four sites on the body (subscapular, triceps, juxta-nipple, and mid-axillary line - xiphoid) were utilized to calculate estimated body fat, according to the equations of Pascale *et al.*,<sup>8</sup> 1956, and Keys and Brozek, 1953.<sup>9</sup>

The data obtained from anthropometric and skinfold measurements during the NATO survey indicate a general progression in body size (based on height, weight, and percent of body fat) from Turkey to Greece to Italy. Minimal skinfold thicknesses are found in measurements of the subsample of Turkish soldiers; hence Turkish troops are estimated to have the lowest mean percentage of body fat (8.0 percent) of any group measured in the NATO survey. This investigation of skinfolds and body fat indicates that Turkish military personnel tend to be relatively lean in build; that Italian military personnel in general are inclined to somewhat more fatness; and that Greek military personnel are intermediate between their Turkish and Italian counterparts in body fat.

<sup>8</sup> Pascale, Luke R., Morton I. Grossman, Harry S. Sloane, and Toby Frankel. Correlations between Thickness of Skinfolds and Body Density in 88 Soldiers. Chapter in: Josef Brozek (editor) **Body Measurements in Human Nutrition**, Wayne University Press, Detroit, Mich., 1956. (Library of Congress Catalog Card No. 56-11646)

<sup>9</sup> Keys, Ancel, and Josef Brozek. Body Fat in Adult Man. *Physiological Reviews*, Vol. 33, No. 3, 280, July 1953.

- 94 WHITE, ROBERT M. Anthropometric Survey of the Royal Thai Armed Forces. (Sponsored by the Advanced Research Projects Agency) U. S. Army Natick Laboratories, Natick, Mass., June, 1964. 62 pages (AD 450 836)

An anthropometric survey of military personnel of the Armed Forces of Thailand was conducted between October, 1962 and March, 1963. The survey was sponsored by the Advanced Research Projects Agency, Washington, D. C. and was authorized by ARPA Memorandum of July 27, 1962, Subject: Anthropometry Research in Southeast Asia.

Body measurements were obtained on a total series of 2950 men, consisting of 2010 of the Royal Thai Army, 610 of the Royal Thai Marine Corps and 330 of the Royal Thai Air Force. Fifty-two measurements were made on each individual. The anthropometric data have been analyzed and are presented in this report in the form of statistical values.

It was found that the average height and weight of Thai military personnel were equivalent to the 5th percentile values of height and weight for United States soldiers. The Thai soldier is about four inches shorter in stature and 30 pounds lighter in weight than the average United States soldier.

The results of the survey, which provide information on the body size of Thai military personnel, may be utilized in the engineering design and sizing of clothing and equipment intended for use by the Royal Thai Armed Forces.

- 95 WHITE, ROBERT M., JOHN L. KOBRICK, and THEODORE R. ZIMMERER. Reference Anthropometry of the Arctic-Equipped Soldier. Technical Report EPT-2, U. S. Army Natick Laboratories, Natick, Mass., August, 1964. 23 pages (AD 449 483)

Space in many military vehicles which can be allotted to the operator and other personnel is becoming ever smaller as mechanical and protective requirements occupy more of the sapce. This report is intended to help the equipment designer to make maximum use of the available personnel space by providing accurate information on the body size of troops dressed in the bulkiest items of Army clothing. Nude body measurements do not accurately serve this purpose because they force the designer to estimate the volume of the clothing.

Data are presented on the body dimensions for the size range of the Army population dressed in the Army arctic clothing ensemble. The information is presented in tabular form, accompanied by diagrams denoting the exact location of the specific dimensions.



- 96 WHITE, ROBERT M. Anthropometry of U. S. Army Aviators. (Paper presented at the Tenth Annual U. S. Army Human Factors Research and Development Conference, U. S. Army Aviation Center, Fort Rucker, Ala., October, 1964). Proceedings, Tenth Annual U. S. Army Human Factors Research and Development Conference, Fort Rucker, Ala., (pp. 147-153), October, 1964.

In the late 1950's, an increasing number of research and development problems in human engineering were coming up in Army aviation. Some of the immediate design problems involved flight helmets, armor, seating, survival kits, and such items of equipment. The lack of any specific information on the range of body size in the Army aviator population became increasingly acute and embarrassing. In order to fill this gap in our knowledge, an anthropometric survey of Army aviators was proposed.

The survey was carried out in October, 1959 by measuring 500 Army pilots, representing at that time about a 10 percent sample of the Army aviation population. Pilots were measured at Fort Bragg, N. C.; Fort Benning, Ga.; Fort Rucker, Ala.; and Fort Devens, Mass. The series consisted of 72 percent commissioned officers and 28 percent warrant officers and included both fixed and rotary-wing pilots. Background information recorded on the subjects included birthplace, age, aeronautical designation, parachutist designation, aeronautical qualification (rating), number of years since rated, and combat flying. This type of information made it possible to describe the sample in detail with respect to qualification and experience.

The anthropometric aspect of the survey consisted essentially of taking 41 body measurements on each man. The body measurements included various standing and sitting heights, lengths, breadths, and circumferences, as well as some measurements of the head and face, the hands and feet. Three skinfold thickness measurements also were taken in order to permit an estimate of body fat.

The Army aviators averaged 30.25 years of age, as compared with 27.9 years for the Air Force flying personnel series, and 24.3 years for the standard Army anthropometric sample. The Army flyers thus averaged about 2 years older than the Air Force and 6 years older than the Army as a whole. These age differences reflect the differences found in body size. The Army aviators were found to be 69.5 inches tall and to weight 165.8 pounds on the average. They were thus one-half inch taller and two pounds heavier than Air Force flying personnel, and one inch taller and eleven pounds heavier than the Army in general. Other body proportions are correspondingly larger or greater.

- 97 WHITE, ROBERT M. Anthropometric Survey of the Armed Forces of the Republic of Vietnam. (Sponsored by the Advanced Research Projects Agency) U. S. Army Natick Laboratories, Natick, Mass., October, 1964. 66 pages (AD 458 864)

An anthropometric survey of military personnel of the Republic of Vietnam was conducted between 28 May and 1 July, 1963. The survey was sponsored by the Advanced Research Projects Agency, Washington, D. C., and was authorized by ARPA Order No. 267, Amendment No. 6, dated 8 May 1963.

Body measurements were obtained on a total series of 2129 men, consisting of 1225 of the Army, 299 of the Navy, 301 of the Marine Corps, and 304 of the Air Force. Fifty-one measurements were made on each individual. The anthropometric data have been analyzed and are presented in this report in the form of statistical values.

It was found that the 50th percentile value for the stature of Vietnamese military personnel is equivalent to the 2nd percentile value for United States soldiers, while the 50th percentile value for the weight of Vietnamese is less than the 1st percentile value for United States soldiers. The average Vietnamese is about five inches shorter in stature and 43 pounds lighter in weight than the average United States soldier.

The results of the survey, which provide information on the body size of Vietnamese military personnel, may be utilized in the engineering design and sizing of clothing and equipment intended for use by the Armed Forces of the Republic of Vietnam.

- 98 WHITE, ROBERT M. Military Anthropometry in Southeast Asia. (Paper presented at the 33rd annual meeting, American Association of Physical Anthropologists, Mexico City, D. F., Mexico, June, 1964). American Journal of Physical Anthropology, N.S. Vol. 22, No. 4, 506, December, 1964.

Abstract: Anthropometric surveys of military personnel were conducted in the Kingdom of Thailand in 1962 and in the Republic of Viet Nam in 1963. They were carried out under the sponsorship of the Advanced Research Projects Agency, United States Department of Defense, Washington, D. C.

During the survey in Thailand, 2,950 men of the Royal Thai Armed Forces were measured, including samples from the Army, Marine Corps, and Air Force. The survey in the Republic of Viet Nam included a series of 2,130 men of the Army, Navy, Marine Corps, and Air Force. In both surveys the measuring was carried out by teams of native military personnel. Approximately 50 body measurements were made on each individual.

Besides summarizing and discussing the results of the surveys, the anthropometry of military personnel in other Asian countries will be commented upon.



- 99 BURSE, RICHARD L. USAF Size Extra-Large Flight Helmet: Comparison of Dimension Specifications with Anthropometric Data. Report No. EPR-6, U. S. Army Natick Laboratories, Natick, Mass., January, 1965. 7 pages (AD 803 966L)

Four internal dimension specifications of the U.S. Air Force design for the size extra-large flight helmet were compared with pertinent anthropometric data from the U. S. Army aviator, and the U. S. Air Force aircrewman populations in order to determine the ranges of men properly accommodated. Three of the specified dimensions were found to properly accommodate the 99.9th percentile and maximum values of both flying populations. One dimension was found inadequate for the maximum values of both populations. Suggested modifications to increase the range accommodated by this dimension are discussed, as are other suggestions to improve fit of the helmet.

100 WHITE, ROBERT M. Man in Terrestrial Environments: The Role of Military Anthropometry in System Development. (Paper presented at a symposium, 35th annual meeting, American Association of Physical Anthropologists, Berkley, Calif., April, 1966). American Journal of Physical Anthropology, N.A. Vol. 25, No. 2, 216-217, September, 1966.

Abstract: An important concept in the area of military research and engineering is represented by the so-called systems approach. According to this concept, the man or the individual soldier, together with his equipment, whether it be a machine he is operating or personal equipment he is wearing or using, is considered to be a man/equipment system. A basic requirement for the effective use and operation of such a system is that the man and the equipment be compatible.

The successful achievement of such compatibility depends upon the satisfactory design and engineering of the equipment in order to provide the best possible utilization and acceptability by the soldier in performing his mission.

Since anthropometric data constitute a basic requisite for defining the elements of body size in the human engineering of man/equipment systems, anthropometry represents an essential input to the development of such systems. Since effective human engineering requires the use of body size data on the specific population for which the equipment is intended, military anthropometry is one source of the information necessary for the design and sizing of equipment and materiel to be used by the Armed Forces.

Anthropometry is the measurement of the human body. Anthropometric data may be collected by measuring large, representative samples of the military population. Through the compilation, processing, analysis and synthesis of such data, it is possible to provide a metric description of the military population for general use in the design and human engineering of military equipment and materiel, and also for specific application in the design, sizing and tariffing of clothing and individual equipment.

Several anthropometric surveys of military personnel have been conducted since 1946. New surveys of all the U. S. Armed Forces are now in progress. These will be reviewed and the availability of such anthropometric data will be discussed.

Anthropometric data on various foreign military populations have become available in recent years. Reference will be made to recent surveys in Turkey, Greece, Italy, Japan, Thailand, Vietnam, and Korea.

Utilization and application of anthropometric data on both U. S. and foreign military populations within the framework of the Army human factors program will be explained and discussed.

- 101 BURSE, RICHARD L. Human Factors Requirements for the Design of Helicopter Aircrewman's Seat and Groin Protective Units. Technical Report 67-28-PR, U. S. Army Natick Laboratories, Natick, Mass., September, 1966. 11 pages (AD 640 891)

The ever-increasing ground combat role of helicopters requires that particular attention be devoted to the man-machine interface between the aircraft and the operating crew. This report summarizes the major human factors requirements to be considered in the design of rigidly armored protective seat and groin units for crew chiefs and door gunners of UH-1 series helicopters. Quantitative design criteria are specified to provide further assistance to designers.

The most important human factors requirements for the design of rigidly armored seat and groin protective units for the seated helicopter aircrewman are discussed. Included are requirements for preventing interference with mission performance, reducing fatigue, and providing a compatible, safe and somewhat comfortable working environment for the fully-equipped aircrewman. Quantitative design criteria for dimensions, contours, cushioning, and location of the seat and groin protective units are specified.



102 DOBBINS, D. A., and C. M. KINDICK. Anthropometry of the Latin-American Armed Forces (Interim Report). Research Report No. 10, U. S. Army Tropic Test Center, Fort Clayton, Canal Zone, May, 1967. 62 pages (AD 654 762)

The U. S. Army Tropic Test Center made anthropometric measurements of a sample of Latin-American military personnel in the Canal Zone from September, 1965 to September, 1966.

A total of 733 trainees were measured — 600 airmen at the USAF Inter-American Air Force Academy and 133 Army personnel at the U. S. Army School of the Americas. Eighteen Latin-American countries are represented in the sample. The average age for the sample was 23 years, average height was 65.5 inches, and average weight 140 pounds.

Percentiles and ranges for 76 physical measurements are presented, including isometric strength and hand-grip measures. Reliability coefficients for strength measurements ranged from 0.73 to 0.87.

Comparisons with Thai and U. S. personnel showed that the Latin-American sample was intermediate between the two on most physical dimensions; however, the Latin Americans were much closer in size to the Thai than to U. S. military personnel.

Photographs illustrating various body builds are shown.

- 103 BURSE, RICHARD L. Human Factors Evaluation of Body-Supported Aircrewman's Buttocks and Crotch Protective Unit; Comparison of Two Heights of Crotch Protector and Three Suspension Systems. Technical Report 68-4-PR, U. S. Army Natick Laboratories, Natick, Mass., July, 1967. 24 pages (AD 658 034)

This report is the second in a series concerned with the human factors implications of body armor for U. S. Army aircrewmen. This series is to assist the designer of body armor by specifying design criteria, human factors evaluation methods, and test results. The research described in this report evaluates one concept for lower body protection of aircrewmen, wherein the protective unit is attached to the user's body rather than to the aircraft seat structure.

The research described was an evaluation of body-supported aircrewmen's buttocks and crotch protective units in which two heights of crotch protector and three different suspension systems were compared with respect to fit, comfort, ease of use, estimated length of time the system could be used, and the adequacy of several dimensions of the protective units.

In general, both types of protective units and all three suspension systems were equally satisfactory. However, one type of suspension system and one height of crotch protector were significantly easier to use, while both crotch protectors were too wide. Subjects desired that the longer crotch protector be shortened and the shorter crotch protector be lengthened to approximately the same length. This desired change apparently was based on factors other than physical discomfort.

104 HART, GARY L., GEORGE E. ROWLAND, and ROBERT MALINA. Anthropometric Survey of the Armed Forces of the Republic of Korea. Contract Report (Contract DA19-129-AMC-480(N)), Rowland and Company, Inc., Haddonfield, N.J. Technical Report 68-8-PR, U. S. Army Natick Laboratories, Natick, Mass., July, 1967. 104 pages (AD 640 891)

Anthropometric and equipment evaluation surveys of the military personnel of the Republic of Korea were conducted between May and November of 1965. Body measurements and equipment evaluation data were obtained on a series of 3747 men (3249 Army, 190 Air Force, 141 Navy, and 167 Marine). Fifty-nine body measurements and twenty equipment evaluation measures were made on each individual.

Of the 59 body measurements taken on Korean soldiers, 39 were directly comparable with data which had been previously collected on U. S. troops. The differences between means of the two samples were statistically significant for 30 of the measures. The means of data from U. S. troops exceeded those for Korean soldiers on 33 of the measures, indicating larger physical size in almost all dimensions.

Korean troops expressed themselves on the question: "Insofar as 'fit' is concerned, the (equipment) supplied by the U. S. Army is. . . ." on a seven-point continuum ranging from "excellent" to "very poor". Respondents filled out a questionnaire containing general statements described above, as well as more specific items relating to grasping, reaching, and positioning the equipment as far as comfort and effectiveness were concerned. Subjects rated the smaller, lighter equipment favorably with respect to ease of handling, and reported considerable difficulty using larger weapons and equipment.



105 BURSE, RICHARD L., and WILLIAM D. CAHILL. Comfort and Stability Ratings for Lincloe Helmet and Suspension Systems Compared to Those for Standard Items. Technical Report 69-3-PR, U. S. Army Natick Laboratories, Natick, Mass., July, 1968. 30 pages (AD 851 167)

The research described in this report compares the comfort and stability of the standard Army system for head protection with an experimental system developed under the Lightweight Individual Clothing and Equipment (LINCLOE) concept. This concept is envisioned to drastically reduce the burden imposed on the front-line soldier by selectively reducing the weight and durability of his individual clothing and equipment. The human factors research accompanying this effort is intended to assist the designers of LINCLOE clothing and equipment by specifying design criteria, human factors evaluation methods, and test results.

A sample of sixteen test subjects awarded comfort and stability ratings to the standard U. S. Army M-1 steel helmet and suspension system, one experimental LINCLOE polycarbonate helmet, and three experimental LINCLOE helmet suspension systems. All occurrences of subjects' touching or readjusting the helmet system were recorded, as were subjective ratings for ease of adjustment of the suspension system, overall comfort, helmet warmth, location of chinstrap, pressure produced by the suspension system, annoyance produced by the suspension system, interference with hearing, noise produced by the helmet/suspension combination, and stability when running, jumping, throwing, crawling, digging, and crawling under a wire obstacle. After scaling, scores and subjective ratings for the four suspension systems and two helmets were analyzed for significant differences.

The standard M-1 steel helmet was generally rated inferior to the experimental polycarbonate helmet for comfort and stability, while the standard M-1 suspension system was generally rated superior to all experimental suspension systems for comfort and stability. One experimental suspension closely approached the stability of the M-1 suspension, however, while a different experimental suspension somewhat less closely approached the comfort of the M-1 suspension. Of the performance tasks utilized in the study, grenade throwing and low crawling appeared to best identify suspension systems which were unstable enough to tip over the fore head and produce visual restriction.

- 106 BURSE, RICHARD L., WILLIAM D. CAHILL, and EARL P. SUMMERS. Comfort and Stability Ratings for Prototype Lincloe Titanium Helmet System. Technical Report 69-20-PR, U. S. Army Natick Laboratories, Natick, Mass., August, 1968. 11 pages (AD 679 031)

The research described in this report compares the comfort and stability of the standard Army system for head protection with an experimental system developed under the Lightweight Individual Clothing and Equipment (LINCLOE) concept. This concept is envisioned to drastically reduce the burden imposed on the front-line soldier by selectively reducing the weight and durability of his individual clothing and equipment. The human factors research accompanying this effort is intended to assist the designers of LINCLOE clothing and equipment by specifying design criteria, evaluation methods, and test results.

Six test subjects awarded comfort and stability ratings for the standard 3.16-pound M-1 steel helmet system and an experimental 1.53-pound LINCLOE one-piece titanium helmet system. The suspension system of the experimental helmet was attached directly to the titanium ballistic shell, obviating the need for a helmet liner.

Subjective ratings were recorded for: ease of adjustment of the suspension system, comfort, helmet warmth, location of chinstrap, interference with hearing, noise produced by the helmet, interference with aiming the carbine, and stability when running, jumping, grenade throwing, and crawling under a wire obstacle. After scaling, differences between the ratings for the experimental and the standard systems underwent t-testing for significance. There was only one significant difference between the two systems: the experimental system was rated as more stable when throwing grenades. It is suspected that the M-1 helmet was rated as inferior on this task because it tipped forward, interfering with vision, while the experimental system did not.

- 107 SCHANE, W. P., D. E. LITTELL, and C. G. MOULTRIE. Selected Anthropometric Measurements of 1640 U. S. Army Warrant Officer Candidate Flight Trainees. USAARL Report No. 69-2, U. S. Army Aeromedical Research Laboratory, Fort Rucker, Ala., February, 1969. 70 pages (AD 688 856)

The results of nine anthropometric measurements made on 1640 U. S. Army warrant officer candidates are presented. The nine measurements were selected as those which contribute most to aircrew workspace design in aircraft.

Comparison of these data was performed against similar measurements conducted upon flying personnel in five separate studies by other military services.



108 WHITE, ROBERT M. Changes in Body Size in American Men. Paper presented at the 3rd Annual Technical Conference, Apparel Research Foundation, Washington, D.C., October, 1969.

Are American men getting larger? Is the general body size of the American male increasing? Questions of this type, frequently asked in recent years, are of more than passing interest, since they form the basis for a considerable amount of discussion and also of speculation. The matter of body size is not only one of general interest, but actually one of considerable importance, particularly with respect to clothing and apparel. Therefore, a discussion of changes in body size in American men, based upon facts and figures, rather than impressions and opinions, may prove both interesting and useful.

Unfortunately, very few reliable anthropometric data are available on the U. S. civilian population. However, a large amount of information on body size in the military population has been accumulated, particularly during the past twenty years.

It is concluded that an analysis of U. S. Army anthropometric data between 1946 and 1966 does indicate some increase in body size in American men, but that, on the average, these increases are generally rather small. A much more important conclusion of this study, however, is that shifts in the distribution of body sizes within the population will result in a requirement for relatively larger numbers or quantities of the larger clothing sizes.

- 109 WHITE, ROBERT M. The Utilization of Military Anthropometry for Aircraft Cockpit Design. In: **Problems of the Cockpit Environment**, (pp. 15-1 — 15-9), Advisory Group for Aerospace Research and Development Conference Proceedings No. 55, NATO-AGARD, March, 1970. (Papers presented at the AGARD Avionics Panel XVIth Technical Symposium, Amsterdam, the Netherlands, November, 1968.)

Since anthropometric data constitute a basic requisite for defining the elements of body size in the human engineering of man/equipment systems, anthropometry represents an essential input to the development of such systems in order to achieve compatibility between the man and his equipment. The analysis and evaluation of anthropometric data are discussed in this paper, with reference to newly available data on the U. S. military population. It is shown that the U. S. data indicate distinct differences in body size between flying and non-flying military personnel, primarily due to a marked difference in age. Finally, some general observations are made regarding the applications of anthropometric data in aircraft cockpit design.

110 KENNEDY, STEPHEN J., and ROBERT M. WHITE. Anthropometric Survey of the Imperial Iranian Armed Forces: Phase III — Technical Summary, and Combat Boot Study Project — Technical Summary. U. S. Army Natick Laboratories, Natick, Mass., May, 1971. 79 pages (AD 728 822)

This Technical Summary combines a report on Phase III of the Anthropometric Survey of the Imperial Iranian Armed Forces and the report on the Combat Boot Study Project which also involves application of the anthropometric data obtained in the first two phases of the imperial Iranian Armed Forces Anthropometric Survey.

In accordance with a request made by IIADF, an anthropometric survey was undertaken by the Combat Research and Evaluation Center at the direction of the Vice Chief of the Supreme Commander's Staff, Lt. General Fereidun Djam. The main objective of the survey was to provide the Imperial Iranian Armed Forces a basis for determining how to improve their uniforms and tariffs.

The collection of data for this program, undertaken by CREC in consultation with the Research Triangle Institute as part of an ARPA program, was completed in 1969.

The application of anthropometric data is a highly complex task involving the generation of patterns in the case of clothing, and footwear lasts in the case of boots. Because of similarities in body proportions and other common aspects of anthropometric data, it was apparent that there was a good chance that a relationship could be established between the anthropometric measurements of IIADF and U. S. military personnel, which could make possible the utilization of U. S. experience in the development of patterns and lasts without the need for initiation of totally new projects.

Preliminary examination of IIADF data indicated that such correlation was possible. This was pointed out by Dr. Kennedy upon his visit to Iran 9–20 April 1971, to representatives both of ARMISH–MAAG and the IIADF.

It was stated that a technical summary would be made in which the application of the anthropometric data generated in the Iranian study would be applied to patterns and lasts in a way in which this information could be used by the Imperial Iranian Armed Forces for the stated objectives. This report, accordingly, includes the technical summary on the application of the anthropometric data to uniforms and to combat footwear, with appropriate recommendations as to actions which could be taken to accomplish the original objectives of the anthropometric survey.

- 111 WHITE, ROBERT M., and EDMUND CHURCHILL. The Body Size of Soldiers: U. S. Army Anthropometry — 1966. Technical Report 72-51-CE, U. S. Army Natick Laboratories, Natick, Mass., December, 1971. 329 pages (AD 743 465)

As a part of the U. S. Armed Forces anthropometric surveys of 1966, a sample of 6682 Army men was measured, including basic trainees, infantrymen, armored crewmen, and aviation personnel. Seventy body measurements were taken on each man. The anthropometric data from this survey are presented and discussed. These new data represent the first major up-dating of body size information on U. S. Army personnel since the Army anthropometric survey of 1946. Changes in the body size of Army men between 1946 and 1966 are discussed and the Army data are compared with anthropometric data from other services.



112 CHURCHILL, EDMUND, JOHN T. McCONVILLE, LLOYD L. LAUBACH, and ROBERT M. WHITE. Anthropometry of U. S. Army Aviators — 1970. Contract Report (Contract DAAG 17-70-C-0055), Anthropology Research Project, Yellow Springs, Ohio. Technical Report 72-52-CE, U. S. Army Natick Laboratories, Natick, Mass., December, 1971. 335 pages (AD 743 528)

This report describes an anthropometric survey of U. S. Army aviators conducted at Fort Rucker, Alabama in 1970. Data for 85 body-size measurements and for several variables describing the socio-military background of the survey subjects were gathered on a sample of 1482 flying personnel. Statistical summaries are presented for each measurement for the entire sample and for five subseries: enlisted men (crew chiefs, mechanics, door gunners), warrant officer and warrant officer candidate trainees, warrant officer rated pilots, commissioned trainees, and commissioned pilots. Summary statistics and percentiles for 80 anthropometric indices and for some 73 anthropometric variables computed from the measured dimensions are given, as is the correlation matrix for the measured variables and age.

- 113 DOBBINS, D. A., and C. M. KINDICK. Anthropometry of the Latin-American Armed Forces (Final Report). USATTC Report No. 7209002, U. S. Army Tropic Test Center, Fort Clayton, Canal Zone, August, 1972. 60 pages (AD 759 949)

The United States Army Tropic Test Center made anthropometric measurements of a sample of Latin-American enlisted military personnel in the Canal Zone from September, 1965 to February, 1970.

A total of 1985 trainees were measured — 1952 airmen at the USAF Inter-American Air Forces Academy and 133 Army personnel at the U. S. Army School of the Americas. Fifteen Latin-American countries are represented in the sample. The average age for the sample was 23 years, average height was 5 feet, 5½ inches, and average weight was 141 pounds.

Percentiles and ranges for 75 physical measurements are presented, including isometric strength and hand-grip measures. Country-by-country comparisons are also presented. In addition, 1790 ABO blood group types are presented by country.

These data represent the only known source of detailed anthropometric information on Latin-American military personnel.

114 KENNEDY, STEPHEN J., RALPH GOLDMAN, and JOHN SLAUTA. The Carrying of Loads Within an Infantry Company. Technical Report 73-51-CE, U. S. Army Natick Laboratories, Natick, Mass., May, 1973. 70 pages (AD 762 559) (Anthropometric data prepared by ROBERT M. WHITE)

The carrying of loads by the infantry involves four distinct problems:

- a. The capacity of the load-carrying equipment, particularly in the pack, in relation to the requirements of various combat missions.
- b. The weight of the load, in relation to the physiological limitations of the soldier himself.
- c. The carrying of man-portable equipment assigned by the TO&E to various military occupational specialists in the infantry company, and other special items of organizational equipment.
- d. How the load can best be distributed and carried.

This study has been intended to bring these problems into perspective, both in relation to what has been done in the past, and what is currently in progress, as well as to indicate some special aspects that should be of concern to designers of equipment intended to be man-portable.

- 115 CLAUS, WILLIAM D., Jr., LAWRENCE R. McMANUS, and PHILIP E. DURAND.  
Development of Headforms for Sizing Infantry Helmets. Technical Report  
75-23-CEMEL, U. S. Army Natick Laboratories, Natick, Mass., June, 1974.  
31 pages (AD 787 277)

A new technique for defining and measuring head shapes was developed and applied in the fabrication of a set of first generation plaster headforms. The design of a unique head measuring device is reported. The device is a clear polycarbonate hemisphere on which are mounted twenty-seven moveable mechanical probes. The hemisphere is placed over a subject's head, and the probes are moved to contact the head and thus define head shape. The probe data from a population of Army men were reduced statistically to yield generalized head shapes. The feasibility of combining this probe technique with classical anthropometric head measurements to yield generalized head shapes of various sizes was demonstrated. A set of first generation headforms was sculptured using specific probe data. Improvements and extensions of the present study are indicated.



116 McMANUS, LAWRENCE R., WILLIAM D. CLAUS, Jr., PHILIP D. DURAND, and MICHAEL KULINSKI. Verification Fit Test of Three-Size Infantry Helmet. Technical Report 75-79-CEMEL, U. S. Army Natick Development Center, Natick, Mass., January, 1975. 44 pages (AD A038 765)

The object of this report is to present the statistical analysis of a fitting test of a three-size helmet system. The test was conducted at Fort Devens, Mass., during July, 1974. Four hundred and three officers and enlisted men of the 10th Special Forces served as subjects.

The anthropometric measurements taken and recorded for each subject's head included circumference, length, breadth, height, glabella to vertex, biaural breadth (ear to ear), and menton to vertex.

The subject was given a helmet size designation according to sizing criteria based on circumference, length, and breadth. The subject was then fitted with a clear polycarbonate helmet shell (with suspension system) of the designated size. Each shell had 13 numbered probe holes. The stand-off was checked by probing the distance of the shell from the head. All probe readings less than 12.7 mm were recorded on the subject's record sheet.

As a result of this fitting test, it was concluded that the three-size infantry helmet system fits the U. S. Army population with a tariff of approximately 20, 50, and 30 percent for the respective sizes of small, medium, and large. The helmet system in three sizes, after a very slight modification to length and width, will have a 12.7 minimum stand-off at all points on the head.

- 117 WHITE, ROBERT M. Anthropometric Measurements on Selected Populations of the World. Chapter 3 in: ALPHONSE CHAPANIS (editor) **Ethnic Variables in Human Factors Engineering**, The Johns Hopkins University Press, Baltimore, Md., 1975. (Library of Congress Catalog Card No. 74-24393) (Based on papers presented at a symposium on "National and Cultural Variables in Human Factors Engineering", held at Osterbeek, The Netherlands, 19-23 June, 1972, under the auspices of the Advisory Group on Human Factors, North Atlantic Treaty Organization)

In the efficient human engineering of man/equipment systems, information on the range of variability in human body size and proportions is of basic importance. Such information is to be found in anthropometric data on the population for which the equipment is intended. Anthropometric data on four basic body dimensions (weight, stature, sitting height, and chest circumference) are presented and discussed to illustrate the range of variability in body size to be found in diverse populations.

- 118 McMANUS, LAWRENCE R., PHILIP E. DURAND, and WILLIAM D. CLAUS, Jr.  
Development of a One-Piece Infantry Helmet. Technical Report 76-30-CEMEL,  
U. S. Army Natick Research and Development Command, Natick, Mass.,  
January, 1976. 47 pages (AD A026 065)

The Army Materiel Development and Readiness Command interlaboratory helmet development program is outlined, and the steps taken to develop a new infantry helmet are reported. The results of studies ranging from anthropometry to wearability were synthesized into a military helmet design. Studies included a mathematical sizing model, human factors compatibility evaluations, heat transfer and transient deformation measurements, suspension system designs, and ballistic materials investigations. The resulting three-size, one-piece, ballistic helmet offers significantly improved protection, fit, comfort, and stability over the standard M-1 helmet and nylon liner.

- 119 WHITE, ROBERT M. Anthropometry as a Variable in Human Factors Engineering. (Paper presented at the 6th Congress of the International Ergonomics Association, College Park, Md., July, 1976). Proceedings, 6th Congress of the International Ergonomics Association, College Park, Md., July, 1976, pp. 131-135. Published by the Human Factors Society, Santa Monica, Calif., July 1976. (Abstract published in *Ergonomics*, Vol. 19, No. 3, 361-362, May, 1976)

One of the fundamental concepts in the field of human factors engineering or ergonomics is represented by the systems approach. According to this concept, the man together with his equipment, whether it be personal equipment he is wearing or using, or a machine he is operating, is considered to be a man/equipment system. A basic requirement for the efficient use and operation of such a system is that the man and the equipment be compatible. Effective human engineering plays an important role in achieving such compatibility. Since anthropometric data constitute a basic requisite for defining the elements of body size in the human engineering of man/equipment systems, anthropometry provides an essential input in the development of such systems.

Anthropometry is the measurement of the human body. Since effective human engineering requires the use of body size data on the specific population for which the equipment is intended, military anthropometry, for example, is one important source of the information necessary for the design and sizing of equipment and materiel to be used by military forces. Similarly, anthropometric data on civilian populations are required for application in the human engineering of industrial man/equipment systems or in the design and development of products for civilian consumer use. Fortunately, more and more anthropometric data have become available in recent years, not only in the United States, but particularly in many other countries. Even a cursory or superficial examination of these data immediately indicate very clearly that marked differences exist in human body size and proportions. Anthropometric data thus serve to emphasize the ranges of variation in human body size. Although human variability has not received sufficient attention in the field of human engineering or ergonomics in the past, it cannot be ignored. More emphasis on the accommodation of human variability is necessary if we are to improve the human engineering of man/equipment systems. The purpose of this paper is to first review available sources of anthropometric data. Secondly, through the examination and discussion of several of the basic dimensions of the human body, some of the parameters of human variability will be indicated as they relate to human engineering.



- 120 LAUBACH, LLOYD L., JOHN T. McCONVILLE, EDMUND CHURCHILL, and ROBERT M. WHITE. Anthropometry of Women of the U. S. Army — 1977; Report No. 1, Methodology and Survey Plan. Contract Report (Contract DAAG 17-76-C-0010), Webb Associates, Inc., Yellow Springs, Ohio. Technical Report NATICK/TR-77/021, U. S. Army Natick Research and Development Command, Natick, Mass., June, 1977. 202 pages (AD A043 715)

An anthropometric survey of U. S. Army women was conducted during the winter of 1976-1977 — the first such survey in 30 years. The survey was planned and carried out in response to the need for current and comprehensive body size and strength data for the women who make up an increasingly large part of the U. S. Army. The main purpose of the survey was to obtain and develop statistical data on body size, workspace parameters, and static muscle strength of U. S. Army women. During the survey, data were obtained on 128 conventional body size dimensions, 14 workspace dimensions, and 9 static strength measurements. Many of the measurements made had not been previously reported for any large-scale survey of women, military or civilian. Other measurements were selected to supplement and complement data already available to provide up-to-date information for use in the design of clothing, protective equipment, workspace and industrial equipment which women in the Army wear, use, operate, or within which they work.

This, the first of a series of reports dealing with this survey, describes the methodology used in the conduct of the survey. Included here are an outline of the survey design, a listing of the landmarks used in defining the dimensions to be measured, and detailed descriptions of the procedures used in making each measurement.

Measurement techniques used in previous large-scale anthropometric surveys of women also are listed here. Thus this report, in addition to reporting the methodology of the present survey, constitutes a comprehensive source book of anthropometric techniques for use with women.

- 121 CHURCHILL, EDMUND, THOMAS CHURCHILL, JOHN T. McCONVILLE, and ROBERT M. WHITE. Anthropometry of Women of the U. S. Army — 1977; Report No. 2, The Basic Univariate Statistics. Contract Report (Contract DAAG 17-76-C-0010), Webb Associates, Inc., Yellow Springs, Ohio. Technical Report NATICK/TR-77/024, U. S. Army Natick Research and Development Command, Natick, Mass., June, 1977. 287 pages (AD A044 806)

This report, the second in a series, summarizes the univariate statistics obtained in an anthropometric survey of women in the U. S. Army conducted at Fort Sam Houston, Texas; Fort McClellan, Alabama; Walter Reed Medical Center, the District of Columbia; and Fort Jackson, South Carolina; during the winter of 1976-1977. This survey, carried out to satisfy the need by the U. S. Army for up-to-date data on the body sizes and strength capabilities of the women who now constitute a substantial portion of its personnel, represents the first major anthropometric survey of Army women since 1946.

Data for 69 body size measurements were obtained on a sample of 1331 women who covered wide ranges of age, rank, and military assignment. Additional data were obtained on subseries of between 200 and 300 women for: (a) other standard body size measurements, (b) workspace measurements, (c) head and face measurements, and (d) static strength measurements. Summary statistics and frequency distributions are given here of all these measurements, plus age.

Full descriptions of the measurement techniques and the design and conduct of the survey have already appeared in the first of this series of reports. Brief definitions, illustrations of measurements, and outlines of the computational and statistical procedures used in preparing this report are included here.

- 122 CHURCHILL, THOMAS, EDMUND CHURCHILL, JOHN T. McCONVILLE, and ROBERT M. WHITE. Anthropometry of Women of the U. S. Army — 1977; Report No. 3, Bivariate Frequency Tables. Contract Report (Contract DAAG 17-76-C-0010), Webb Associates, Inc., Yellow Springs, Ohio. Technical Report NATICK/TR-77/028, U. S. Army Natick Research and Development Command, Natick, Mass., July, 1977. 351 pages (AD A046 692)

In this report, the third in a series, over 300 bivariate frequency tables, based on the data from the 1976-1977 anthropometric survey of U. S. Army women, are presented to facilitate the use of these data by designers of clothing, equipment, and workspaces which Army women will wear or use. A bivariate frequency table of anthropometric data indicates the number or proportion of a group of individuals who fall within a particular range of values for one variable or dimension and, simultaneously, within a specified range for a second variable. Thus the bivariate table shows the range of two anthropometric measurements and the numbers or frequencies of women who have the various possible combinations of values of the two measurements.

Ninety-seven bivariate tables are presented with the dimensional data expressed in inches; in twenty-three of these the frequencies are shown in truncated form with the elimination of a few of the extreme values. The remaining 210 bivariates are given with the dimensional data shown in centimeters. Coefficients of correlation, expressing the degree of relationship between the two measurements also are given, together with the regression equations for the two related measurements.



- 123 McCONVILLE, JOHN T., EDMUND CHURCHILL, THOMAS CHURCHILL, and ROBERT M. WHITE. Anthropometry of Women of the U. S. Army — 1977; Report No. 5, Comparative Data for U. S. Army Men. Contract Report (Contract DAAG 17-76-C-0010), Webb Associates, Inc., Yellow Springs, Ohio. Technical Report NATICK/TR-77/029, U. S. Army Natick Research and Development Command, Natick, Mass., July, 1977. 237 pages (AD A048 591)

This report, the fifth in a series which deals with the results of an anthropometric survey of 1331 U. S. Army women, presents comparable data resulting from the measurement of 287 Army men. The opportunity to secure measurements on male subjects made by the same technicians at the same time and place, and using precisely the same measuring techniques, provided a unique source of comparative data for the design, of Army clothing, equipment, and workspaces which, increasingly, must accommodate the wide range of sizes represented by both sexes.

The men's survey was carried out at Fort Jackson, South Carolina, in early 1977. The subjects represented a homogeneous group, chiefly trainees with a median age of about 19 years. The sample was composed of approximately two-thirds Whites, one-third Blacks, and a small fraction of Orientals.

This report describes the conduct of the survey on men and includes the univariate summary statistics and frequency tables resulting from it. Data obtained in the survey included 44 of the 69 body size measurements made on Army women and 13 of an additional 24 standard body dimensions measured on the women, as well as three identical subseries of workspace, head and face, and static strength measurements. Also provided are 51 selected bivariate frequency tables.



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